SPENT FUEL WORKING GROUP REPORT

on

INVENTORY AND STORAGE
OF THE DEPARTMENT'S SPENT NUCLEAR FUEL
and other
REACTOR IRRADIATED NUCLEAR MATERIALS
AND THEIR ENVIRONMENTAL,
SAFETY AND HEALTH VULNERABILITIES

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FOREWORD

This report presents a comprehensive baseline assessment of the condition of spent fuel and other irradiated materials stored at Department of Energy facilities. The product of an intensive three-month effort, this vulnerability study furnishes a qualitative, though detailed, picture of the conditions or weaknesses at DOE facilities that might lead to releases of radioactive materials to the environment or radiation exposure of workers or the public.

The *Spent Fuel Working Group Report* is significant for two reasons. First, the report is a snapshot of current situations and conditions that should help focus the difficult task of safely storing the Department's spent fuel inventory. When Secretary O'Leary commissioned this study in August 1993, a number of technical problems associated with prolonged storage of irradiated materials were apparent, and the Assistant Secretary for Environmental Restoration and Waste Management created an office dedicated to spent fuel issues. However, there was no Department-wide appraisal of such problems that could facilitate short and long-term management decisions.

Second, this report represents a new approach to the problems that confront the Department of Energy. The Working Group process was a cooperative effort involving federal employees from multiple DOE headquarters programs, Field Offices, and contractors. It embodies a willingness to acknowledge weaknesses and vulnerabilities at DOE sites and a commitment to vigorous leadership in the search for solutions to identified problems. The report also demonstrates that the institutional descendant of the Manhattan Project can marshal tremendous technical expertise and that it is possible to rapidly assemble valuable and credible information in a manner that is useful to decision makers and the public.

The irradiated materials described herein are part of the complicated legacy of the first half century of the nuclear age and have many sources. Some materials resulted from experiments with nuclear power generation; some flow from the waste streams of nuclear weapons production; and some materials were partway through the manufacturing processes that produced components for nuclear warheads when safety concerns or changing international realities halted weapons production. There are significant environmental, safety, and health vulnerabilities associated with some of these materials as presently stored. Radiation exposure of workers who operate these facilities is a particular concern.

The Department of Energy and its predecessor agencies have been criticized for having failed to anticipate the environmental consequences of nuclear weapons production and for having failed to devote sufficient care to waste management practices and protection of worker and public health. There are few simple solutions to the sobering problems depicted in this report. The resolution of these matters must begin by ascertaining what we know — and what we do not yet understand — about the products of our efforts to wield the power of the atom.

Tara O'Toole

Tara O'Toole, M.D., M.P.H.
Assistant Secretary
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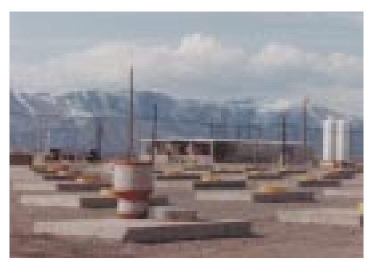
Contents

105-K Reactors, Hanford Site



ICPP-749 Underground Storage Facility, Idaho National Engineering Laboratory Site

(Cover photo of Volumes II and III)

1.1 INTRODUCTION

The Department of Energy is storing large amounts of spent nuclear fuel and other reactor irradiated nuclear materials (herein referred to as RINM). In the past, the Department reprocessed RINM to recover plutonium, tritium, and other isotopes. However, the Department has ceased or is phasing out reprocessing operations. As a consequence, Department facilities designed, constructed, and operated to store RINM for relatively short periods of time now store RINM, pending decisions on the disposition of these materials. The extended use of the facilities, combined with their known degradation and that of their stored materials, has led to uncertainties about safety.

To ensure that extended storage is safe (i.e., that protection exists for workers, the public, and the environment), the conditions of these storage facilities had to be assessed. The compelling need for such an assessment led to the Secretary's initiative on spent fuel, which is the subject of this report.

This report comprises three volumes:

Volume I — Summary Results of the Spent Fuel Working Group Evaluation
Volume II — Working Group Assessment Team Reports and Protocol
Volume III — Operating Contractor Site Team Reports

This volume presents the overall results of the Working Group's Evaluation. The group assessed 66 facilities spread across 11 sites. It identified: (1) facilities that should be considered for priority attention, (2) programmatic issues to be considered in decision making about interim storage plans, and (3) specific vulnerabilities for some of these facilities.

1.2 SPENT FUEL WORKING GROUP

On August 19, 1993, the Secretary assigned to the Office of Environment, Safety and Health (EH) the responsibility for leading the Department's initial assessment of the environmental, safety, and health (ES&H) vulnerabilities associated with the storage of RINM (Reference 1). On September 2, 1993, the Acting Assistant Secretary for Environment, Safety and Health provided additional guidance to implement the Secretary's initiative (Reference 2). This guidance outlined an organizational framework and approach, emphasizing intra-Departmental teamwork and cooperation to perform this assessment.

DOE Operations Offices, the Laboratories, and Management and Operating (M&O) Contractors designated site personnel with the best technical knowledge of the inventory data, operations, and safety bases for the storage facilities under their cognizance to participate in the assessment process. These personnel and other participants from the Cognizant Secretarial Offices, Operations Offices, and EH formed a DOE Spent Fuel Working Group.

The Working Group has served to (1) plan and coordinate the activities of this initiative, (2) collect and validate site and facility information on inventories and potential vulnerabilities, (3) collectively evaluate and characterize the potential vulnerabilities, and (4) prepare this initial report to the Secretary. Throughout the assessment, a strong liaison was maintained between the Working Group and the Office of Spent Fuel Management and Special Projects (EM-37), which is conducting a more extensive and longer term review of the issues surrounding the Department's spent fuel storage. Figure 1 shows the Working Group process.

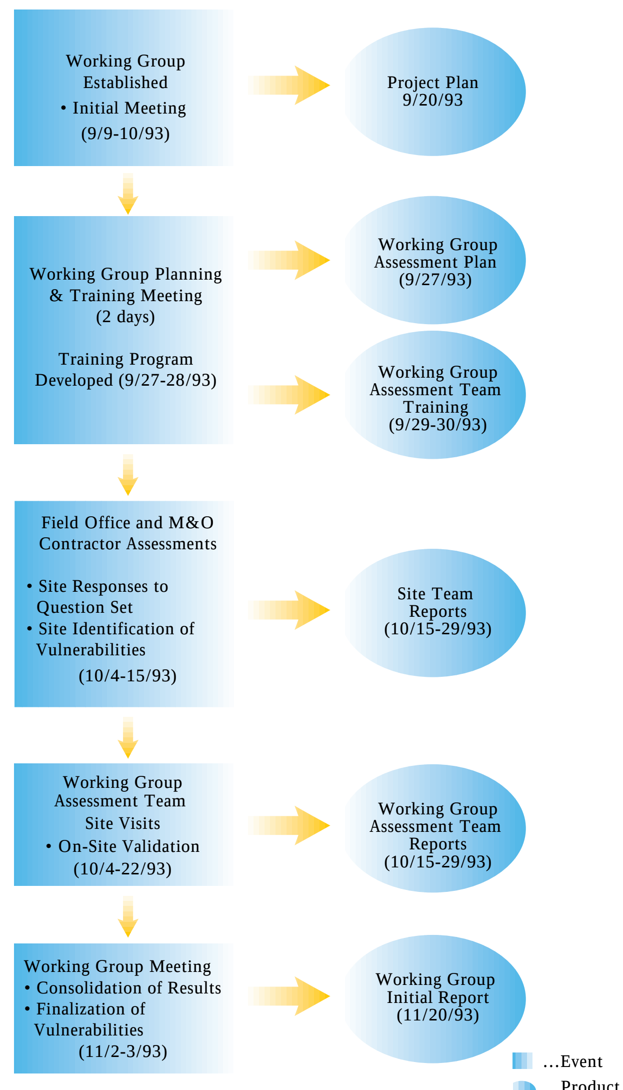


Figure 1 - Working Group Process

The Working Group first met on September 9, 1993, to develop the Project Plan (Reference 3). Information on inventory and vulnerabilities was collected at 11 sites by both Site Teams and Working Group Assessment Teams, following the guidance and procedures given in the Project Plan and the Working Group Assessment Plan (Reference 4). Their reports are summarized in Chapter 2. During the week of November 1, 1993, the Working Group again met to review and characterize the information reported by the Site and Working Group Assessment Teams and to prepare this report.

1.3 OBJECTIVE AND SCOPE

The Project Plan established the objective and scope of the assessment. Accordingly, the plan clarified the following:

- The project's objective was to provide an itemized inventory of RINM and an initial assessment of the environmental, safety, and health vulnerabilities associated with the current storage and handling of these materials, Box 1.

BOX 1 - VULNERABILITIES

"...identify, characterize and assess the safety, health and environmental vulnerabilities of the Department's existing storage conditions and facilities..."

Hazel R. O'Leary
August 19, 1993

What Are Vulnerabilities?
Vulnerabilities in nuclear facilities are conditions or weaknesses that may lead to radiation exposure to the public, unnecessary or increased exposure to the workers, or release of radioactive materials to the environment. For example, some DOE facilities have had leakage from spent fuel storage pools, excessive corrosion of fuel causing increased radiation levels in the pool, or degradation of handling systems. Vulnerabilities are also caused by loss of institutional controls, such as cessation of facility funding or reductions in facility maintenance and control.

- RINM was defined as spent nuclear fuel (in any condition) and irradiated nuclear targets from production and research reactors. (These materials have been withdrawn from nuclear reactors following irradiation. Only in a few cases do they reside within inactive reactors. The constituent elements of these materials have not been separated by processing.)
- Fuel currently in active reactors was to be considered outside the project's scope.
- Reactor waste products and reactor irradiated structural materials (other than fuel cladding) were to be considered outside the project's scope.
- Other radioactive and hazardous materials stored in the facilities were to be identified and evaluated to the extent that they might contribute to environmental, safety, and health vulnerabilities.
- Evaluations were to be made of facilities, structures, systems, operating conditions, and procedures necessary to protect the workers, the public, and the environment during the storage and in-facility handling of RINM.
- The assessment was to focus on determining ES&H vulnerabilities and presenting factual information. In general, future corrective actions were not to be identified or recommended, but corrective actions already underway were to be assessed.

In conducting the assessment, the Working Group focused on 11 sites, where Department of Energy RINM are stored in basins, pools, canals, canyons, inactive reactors, warehouses, hot cells, vaults, wells, casks, and burial grounds.

The following eight sites contain Department-owned storage facilities:

- Hanford Site
- Idaho National Engineering Laboratory Site (INEL)
- Savannah River Site (SRS)
- Oak Ridge Site
- Brookhaven National Laboratory (BNL)
- Argonne National Laboratory-East (ANL-E)
- Los Alamos National Laboratory (LANL)
- Sandia National Laboratories (SNL)

Department-owned spent fuel also is stored at the following three non-Departmental facilities:

- West Valley Demonstration Project Site
- Babcock & Wilcox, Lynchburg Technology Center
- General Atomics

Subsequent to the initiation of this assessment, the Operations Offices identified small amounts of Department-owned RINM stored at Rocky Flats, Mound, Lawrence Berkeley Laboratory, Battelle Columbus Laboratory, and some university reactors. The Working Group Assessment Teams did not visit these sites, but information about the materials stored there is provided in Chapter 2 of this report.

1.4 METHOD

The inventory and vulnerability assessment was conducted in accordance with the Project Plan (Reference 3) and Working Group Assessment Plan (Reference 4). Thirteen Site Teams, consisting of M&O contractor and Operations Office personnel, obtained inventory and ES&H information about their storage facilities. They responded to the question sets in the Project Plan and used the plan's procedure to identify most of the vulnerabilities found in this assessment.

The seven Working Group Assessment Teams consisted of members of the Spent Fuel Working Group, who were assigned to assess sites other than the ones where they have responsibilities. EH staff members, and EH and EM-37 consultants also participated. These teams visited the sites between October 4 and 22, 1993. They met with the respective Site Teams to review drafts of the site operating contractor team report and to walk down the storage facilities. As vulnerabilities were identified, the Working Group Assessment Teams shared them with the Site Teams.

The Working Group Assessment Teams met again on October 22 through 29, 1993, to discuss their assessments and characterize vulnerabilities by using the method prescribed in Section 4.4 and Attachment 5 of the Project Plan. See Figure 2.

The entire Working Group reviewed the overall vulnerability assessment and characterization process during its meetings on November 2 and 3, 1993. The next section presents the results of this process.

Figure 2-Vulnerability Characterization Process

1

Provide information and data in response to the Question Set.

Question Set
Information and Data

1. RINM Inventory
2. RINM Material Condition
3. Water/Coolant Quality
4. Facility Condition
5. Open ES&H Issues
6. Facility Authorization Basis
7. Institutional Controls
8. Other ES&H Concerns

2

Review Question Set information and data and look for certain conditions and symptoms.

Conditions and Symptoms

1. Moderator Problems
2. Geometry Problems
3. Inventory Uncertainties
4. Reflection Problems
5. Poison Problems
6. Institutional Control Problems
7. Migration/Accumulation of Fissile Material
8. Others

9. Loss of Cooling
10. Corrosion
11. Hazardous Material ID
12. Structural Integrity Clad/Can
13. Coolant Activity
14. Coolant Quality Monitoring (water, air, Na, etc.)
15. Monitoring Well Activity
16. Pool Leakage
17. Confinement
18. Contamination

19. Loss of Shielding
20. Buried Material
21. Handling Systems

22. Authorization Basis
23. Training and Qualification
24. Surveillance and Maintenance
25. Conduct of Operations
26. Radiation Protection
27. Industrial Hygiene
28. Occurrence Reporting
29. Permits
30. QA/Records
31. External Oversight History
32. Seismic and Other Natural Phenomenon Hazards

3

Review conditions and symptoms and identify potential adverse conditions.

Adverse Conditions

1. Criticality

2. Radioactive Material Release

3. Radiation Exposure

4. Institutional Control Failures

4

Category of Interest

1. Environment
2. Public Health and Safety
3. Worker Health and Safety

Assign adverse conditions to affected categories of interest to identify ES&H hazards.

Make a judgement on how soon potential Adverse Conditions need management attention.

Timing

1. Within the next year
2. Within the next 5 years
3. >5 years

5

Working Group Assessment Teams characterize ES&H vulnerabilities.

1.5 RESULTS

The results are summarized in the following five sections. Section A describes the RINM inventory. For each of the three categories of facilities (wet, dry, and buried), Section B describes the facilities in which the inventory is stored, the current condition of the RINM and the facilities, and the vulnerabilities for each category. This section follows the vulnerability identification and characterization process displayed in Figure 2. Through analysis of the vulnerabilities, generic issues surfaced common to all facility categories. These are described in Section C. The facilities with the most significant vulnerabilities are described in Section D. Section E describes the Department's better storage facilities. Attachment A includes a complete list of acronyms used in this report. A summary of the conclusions is shown in Box 2.

BOX 2 - CONCLUSIONS

Action Plans are needed to address safety and environmental issues involving our storage of spent nuclear fuel and other nuclear materials.

• Five facilities and three burial grounds warrant priority management attention to avoid unnecessary increases in worker radiation exposure and cost during clean up. These facilities are:

- Hanford 105-K East Basin
- Idaho Chemical Processing Plant-603 Underwater Fuel Storage Facility (ICPP-603 FSF)
- Savannah River L-Reactor Disassembly Basin
- Savannah River K-Reactor Disassembly Basin
- Hanford PUREX Canyon
- Hanford 200 West Area Burial Grounds
- Oak Ridge Classified Burial Grounds
- Oak Ridge Homogeneous Reactor Experiment (HRE) Disposal Wells

• Five fundamental issues should be addressed and tracked for each storage facility to facilitate future decision making. These are 1) the adequacy of the facility's authorization basis, 2) its resistance to seismic events, 3) whether it has clear Departmental programmatic ownership and funding, 4) the extent to which the material it contains is fully characterized, and 5) whether realistic plans exist to disposition its material.

• These vulnerabilities identified by the Working Group should be considered in facility specific action plans.

• Site wide plans for near term disposition of material by individual facilities must recognize the reality of existing constraints involving the availability of suitable qualified shipping casks, the storage capacity and commitments of potential receptors, and commitments to state governments.

A. RINM CHARACTERISTICS AND INVENTORY

RINM include spent nuclear fuel and a variety of reactor irradiated target materials for production of plutonium, tritium, and other isotopes. These materials have been withdrawn from reactors following irradiation. In some cases, they are stored in the inactive reactors. Their constituent elements have not been separated by reprocessing. Spent nuclear fuels include fuel irradiated in commercial power reactors, fuel irradiated for production of plutonium within the fuel itself (Hanford N-Reactor and Single Pass Reactors), driver fuel irradiated in reactors containing special targets for production of plutonium and tritium (Savannah River reactors), and fuel irradiated in several types of research and experimental reactors High Flux Isotope Reactor (HFIR) at Oak Ridge; High Flux Beam Reactor (HFBR) at BNL; Fast Flux Test Facility (FFTF) at Hanford; Power Burst Facility (PBF), Material Test Reactor (TRA-603 MTR), Transient Reactor Test Facility (TREAT), Experimental Breeder Reactor II (EBR-II), and Zero Power Physics Reactor (ZPPR) at INEL; university reactors; and others.

Spent nuclear fuels contain highly radioactive materials of various kinds in addition to leftover fissile and non-fissile uranium. They also contain fission products such as Strontium-90, Cesium-137, and many other radionuclides, several types of activation products, including actinides and transurancis formed by neutron absorption by uranium and structural materials during irradiation, and newly created fissile materials such as Plutonium-239, and Uranium-233.

Quantities of the radioactive materials in the spent nuclear fuels depend on the degree of fuel irradiation in the reactors, usually referred to as fuel burnup. Fuel with higher burnup contains more of the radioactive products of irradiation. Irradiated target materials for plutonium production also have similar types of radioactive materials (as in the spent fuel) produced in them during irradiation. Irradiated targets for tritium production have tritium and radionuclides of lighter elements.

Cladding materials that confine the RINM include zircaloy, stainless steel, inconel, aluminum, graphite, ceramic, and other material. RINM forms includes assemblies, rods, elements, tubes, blocks, plates, and other types. Some RINM may have developed damage to the cladding during irradiation.

DOE's inventory of RINM listed in Attachment B includes:

- Production Reactor Fuel and Targets
- Commercial Nuclear Reactor Fuel
- Research Reactor Fuel
- Naval Reactor Fuel

The Department owns and stores approximately 2,700,000 kg of RINM. This consists of enriched and natural uranium; plutonium, thorium, and other heavy metals; light metals such as lithium; and fission and activation products. The total mass of the material stored actually is considerably higher because it includes fuel assembly structural material and fuel and target cladding.

The Site Teams collected the key information at each site, and the Working Group Assessment Teams validated the data during their site visits. Prior to this effort, the Office of Spent Fuel Management and Special Projects (EM-37) developed a detailed Spent Fuel Inventory questionnaire to be answered by all facilities storing DOE spent fuel.

Because many of the questions that EM-37 and the Working Group asked were the same, the facility responses to the EM-37 questionnaire were used as the baseline for inventory information whenever possible, thus avoiding duplication of effort. The Site Teams and Working Group Assessment Teams corrected the responses, based on revised information, and gathered data on material not included in the questionnaire. The data are presented in condensed form in Attachment B.

1. CATEGORIES OF MATERIAL STORED

Production reactor fuel and targets constitute most of the DOE RINM inventory. These are stored at both Hanford and Savannah River. Hanford stores the most.

Commercial reactor fuel is stored as the result of the shutdown of early demonstration reactors, such as Elk River and Saxton, and as the result of the Department's agreements to take other fuel into inventory. Reactor core debris from Three Mile Island Unit 2 and spent fuel from the Shippingport Light Water Breeder Reactor stored at Idaho, and commercial reactor fuel assemblies stored at West Valley, make up most of this material.

Research reactor spent fuel makes up a very small percentage of the material stored, but includes material from a very large number of reactors and experiments, including foreign reactors.

Naval Reactor fuel is stored at INEL in the Expended Core Facility (ECF), ICPP-603 FSF, and ICPP-666 Underwater Fuel Storage Area (ICPP-666 FSA). This fuel comprises less than 1% of the total inventory when expressed as irradiated heavy metal. Chart 1 shows this breakdown.

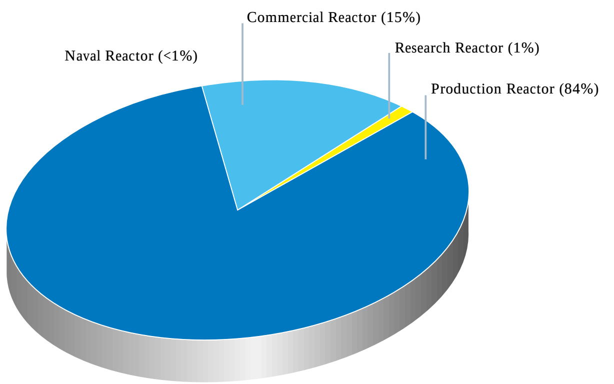


CHART 1 - RINM SOURCES AS IRRADIATED HEAVY METAL

2. TYPES OF CLADDING

Hanford N-production reactor irradiated materials and commercial reactor fuels are mainly clad with zircaloy; Hanford single pass reactor fuel is clad with aluminum. These constitute most of the materials stored. Savannah River production reactor fuel and targets and many research reactor fuels are clad with aluminum. Also in storage is some stainless-steel-clad fuel, primarily from the EBR II and Training, Research, Isotopes, General Atomics (TRIGA) reactors, as well as some special fuels, such as the graphite/carbon-clad fuels, from Peach Bottom I and Fort Saint Vrain.

3. STORAGE LOCATIONS

Ninety-nine percent of DOE RINM is stored in four locations:

- Hanford—primarily production reactor irradiated materials
- Idaho National Engineering Laboratory—naval reactor, commercial fuel, research reactor fuel
- Savannah River—production reactor fuel and targets, commercial fuel, research reactor fuel
- West Valley—commercial reactor fuel assemblies

B. ES&H VULNERABILITIES

1. WET STORAGE

RINM has been stored in pools since clad nuclear reactor fuel elements were first developed. Over 100 commercial and DOE storage pool facilities exist within the United States. Wet storage remains the preferred technology for irradiated materials that require cooling to remove decay heat and shielding to protect workers from radiation. Technology standards applied since the 1970s (mostly in commercial reactors) have included the use of stainless-steel-lined pools, filtered and chemistry-controlled water, and filtered confinement atmospheres. Most commercial fuel stored in such pools is clad in zircaloy, which offers significant resistance to corrosion. Further, it is common commercial practice to encapsulate failed fuel to isolate it from the storage water.

Department storage pools, which were built as long ago as the 1940s, do not meet commercial and DOE nuclear standards. Several DOE orders address RINM storage facilities indirectly. DOE 6430.1A sets out design criteria that address storage facilities, Box 3.

Further, many of the fuel/cladding types stored in the pools are not corrosion-resistant. This has resulted in a number of storage vulnerabilities, many of which challenge the environment and the health and safety of workers. A summary of the facility, pool, and fuel characteristics for wet storage is provided in Attachment C.

- WET STORAGE FACILITY CHARACTERISTICS

There are 29 DOE fuel pool facilities, which range in age from 10 to over 40 years. Facilities over 30 years old were constructed to standards far less rigorous than exist today, Box 3. Most Department storage pools were not designed for long term spent fuel and target storage and have little space available for consolidation.

Most Department storage pool surfaces are bare concrete, a few are coated with epoxy or vinyl, and a few are lined with stainless steel. The unlined pools are more susceptible to leakage as well as to increased contamination by soluble radionuclides, such as Cesium-137. Unlined pools do not have effective leak-detection systems that can detect or capture leaks through the first barrier. In many pools, leaks are detected through indirect measurements, such as water level and makeup water. Due to evaporation, these methods create uncertainty as to true leakage.

Groundwater monitoring wells have been installed around more than 50% of DOE storage pools as another way to identify pool leakage. Tritium has been detected in monitoring wells near some pools. In some cases, because other sources of tritium exist and may reach the groundwater, a pool cannot be identified with certainty as the source.

Severe corrosion of materials has occurred at many DOE storage pools. Generally, corrosion is attributed to poor water quality control and material incompatibilities. The use of incompatible materials may result in pitting and galvanic corrosion. Corrosion has degraded lifting, handling, and storage equipment. This can lead to problems during RINM movement. In some cases, failure of equipment could cause fissile-material reconfiguration, which could raise nuclear criticality concerns.

BOX 3 - CURRENT DOE REQUIREMENTS FOR IRRADIATED FISSILE MATERIAL STORAGE FACILITIES DOE 6430.1A (4/6/89)

These requirements shall be applied in the planning and design of new or modification of existing spent fuel storage facilities. The Section 1320 of this Order applies to a WATER POOL TYPE or DRY TYPE of storage facility. Spent fuel storage facilities that are part of a reactor facility are not covered by this; they are covered by DOE 5480.6.

OBJECTIVES: To ensure that conservatively estimated consequences of NORMAL operations and CREDIBLE ACCIDENTS are limited within the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.

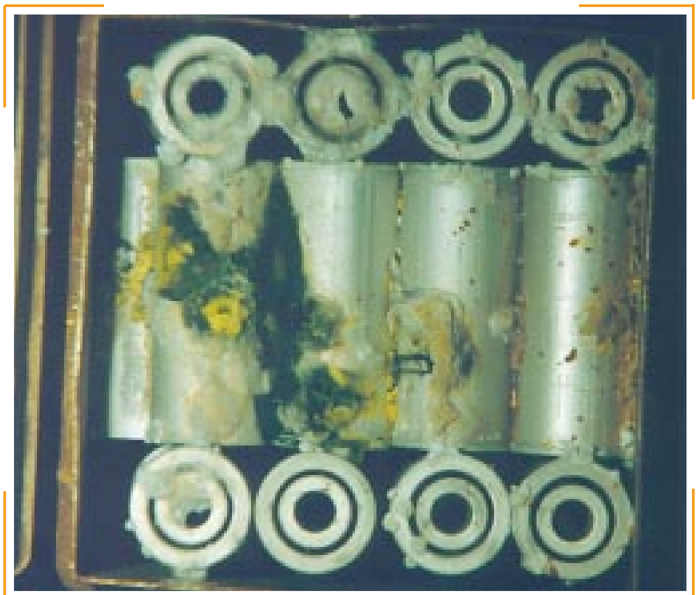
CRITICALITY SAFETY: Favorable geometry, as implemented by storage rack design, is the preferred method of implementing nuclear criticality safety. Storage racks shall be designed as safety class items and maintain their integrity during and following a design basis accident.

DESIGN CONSIDERATIONS: Criteria provided in 10 CFR 72 and NRC R.G.s 3.49 and 3.54 for applicability are to be considered. Requirements include:

1. Pool shall be designed as a safety class structure.
2. Cooling water system shall be safety class and shall be capable of limiting maximum pool temperature to 110 degrees fahrenheit. A passive safety class cooling system shall be used for a dry type storage facility.
3. Pool water cleanup system shall be provided to maintain water clarity, ensure long-term cladding integrity, ensure structural integrity of the storage racks and other submerged structures. Filters shall be capable of being either remotely backflushed or designed so that cartridges can be removed directly into a shielded container. Instrumentation for periodic functional testing of pool water cleanup system and heat exchangers shall be considered.
4. Systems shall be incorporated that can detect leakage from stored fuel in the event of a cladding or canning failure.
5. Primary confinement shall be the corrosion-resistant fuel cladding or canning. Secondary confinement shall be established by the facility buildings that enclose the dry storage area and/or the storage pool and auxiliary systems. Penetrations of the secondary confinement barrier shall have positive seals to prevent the migration of contamination. Areas of higher potential airborne contamination shall be kept less than atmospheric pressure.
6. The building shall be designed to prevent massive collapse of building structures or the falling of heavy objects onto the stored fuel as a result of building structural failures.
7. Nuclear criticality safety shall be considered in the design of effluent control and monitoring systems. All exhaust outlets that may contain transuranics or fission products shall be provided with two monitoring systems.
8. For water pool type facilities, the pool liner with a leakage collection system that will allow leakage detection and limit absorption of contaminated pool water by concrete structures shall be considered.

Radiation levels within many Department storage pools are elevated as a result of fuel or target material corrosion. Control of these radiation levels is adversely affected by absorption of radionuclides in bare concrete and ineffective pool cleanup systems. However, most continuously occupied work locations in the facilities are maintained at radiation exposure rates less than a few millirems per hour.

Significant quantities of sludge and debris exist at several facilities. Sludge and debris are the result of intrusion of dust from the environment, deterioration of concrete walls, and corrosion of fuel, target, and structural components. Sludge, which is highly mobile, can result in high radiation levels and problems with visibility. Accumulation in locations such as sand filters and backwash pits has created nuclear criticality limit concerns at some facilities.



1 - Corroded Reactor Target Slugs in Stainless-Steel Storage Basket, L-Reactor Disassembly Basin, Savannah River Site

Many facilities do not meet today's design requirements to protect against seismic events and other natural phenomena. Corrosion of RINM and storage equipment increases the vulnerability to natural phenomena, particularly radionuclide release to the facility or environment. Some Department storage facilities have no confinement systems. Others have negative pressure, High-Efficiency Particulate Air (HEPA) filtered ventilation systems that serve as a final barrier to radionuclide release. However, the Idaho Test Area North Pool (TAN-607) is maintained at positive pressure, which is inappropriate for facilities with the potential for radionuclide release.

• Wet Storage RINM Characteristics

Residence time in the pools of some RINM is about 30 years. The cladding of significant amounts of stored RINM has been breached due to corrosion or physical damage. When corrosion penetrates the cladding, the reactions of fuel and target material with water can cause the cladding to swell and accelerate deterioration. Corrosion of fuel and targets can result in release of fissile materials as well as fission and activation products. Problems with handling this fuel will increase significantly over time, Photo 1.

Aluminum-clad RINM is subject to rapid corrosion in pools without careful chemistry control. It is also incompatible with other metals and experiences galvanic corrosion. Zircaloy-clad fuels are much more corrosion-resistant. Some failed fuels have been encapsulated to minimize the impact of cladding failures.

• Wet Storage Issues And Vulnerabilities

Originally, most Department fuel and targets were intended to be processed, with the resulting components separated into those for recycle/reuse and those for waste disposal. Programmatic decisions have caused reprocessing to stop at Hanford and Idaho, and have delayed reprocessing at Savannah River. Some RINM in basins at those sites has been stored since the early 1960s. At other sites, RINM also is being retained in interim storage because reprocessing is unavailable. Storage of RINM on an open-ended basis is an institutional failure that leads to ES&H vulnerabilities as follows:

- The potential exists for the release of radionuclides as a result of pool leakage. The pool is the last barrier to fission product release to the environment. Several pools are leaking and monitoring techniques for leakage are inaccurate. Some pools suspected of leaking have tritium in nearby monitoring wells. Hanford 105-K East Basin monitoring wells show sharp increases in tritium that are coincident with leak increases. Continuing degradation in these pools will likely result in increased leakage and environmental releases. (See the related discussion of the 105-K East and 105-K West Basins, SRS Disassembly Basins, TAN-607, TRA-603 MTR, ICPP-603 FSF, and West Valley in Chapter 2.)
- The release of radionuclides and fissile material to the pools occurs as a result of corrosion. Corrosion also creates handling, packaging, inventory control, waste generation, and cleanup problems. (See the related discussion of 105-K East Basin, SRS Disassembly Basins, ICPP-603 FSF, and Hanford PUREX in Chapter 2.) These problems manifest themselves in additional work and increased worker exposure. Radiation levels at ICPP-603 FSF and 105-K East Basin are much higher than other pools due to Cesium-137 present in water and/or absorbed into concrete. The unplanned relocation of fissile material may have some, albeit low, probability of causing criticality events. (See the related discussion of the ICPP-603 FSF and the 105-K East Basin backwash pit in Chapter 2.) The fission and activation product release presents a direct environmental vulnerability.
- Structural and handling equipment weakened by corrosion can increase the probability of accidents with the potential for radionuclide releases and geometry changes, which can lead to criticality concerns. Heavy load drops could challenge the structural integrity of a pool. (See the related discussion of the SRS Disassembly Basins, SRS F- and H-Canyon Basins, and PUREX in Chapter 2.)
- The potential for release of radionuclides to the environment, exposure to workers, or criticality concerns results from natural phenomena (e.g., earthquakes, tornados). Department pool facilities were designed to standards of engineering and construction that are generally lower than those accepted today. Many of the facilities currently used for storage were designed for other purposes. In addition, structural degradation of fuel pools, handling equipment, and storage equipment increases the potential for damage in a seismic event. (See the related discussion of Hanford T-Plant, TAN-607, TRA-603 MTR, ICPP-603 FSF, LANL Omega West Reactor (OWR), HFBR, and SRS Disassembly Basins in Chapter 2.)

Wet storage facilities are overwhelmingly characterized by adverse conditions associated with fission product release. Most vulnerabilities identified have impact on the workers and have less impact on the environment, and significantly less on the public.

2. DRY STORAGE

Throughout the Department complex, a wide variety of dry storage types and applications are used, including hot cells, dry wells, casks, and vaults.

RINM has been examined and stored in dry configurations within hot cell facilities since the 1950s. Usually, hot cells are robust with quality confinement systems. However, because most Department hot cell facilities were designed and built primarily to conduct tests and basic research on irradiated fuels, they have very limited storage capacity. They are not intended or designed to store RINM over the long term.

Since the 1970s, RINM has been stored in facilities specifically engineered for longer term dry storage. Once the material removed from reactors has cooled sufficiently, dry storage methods have been employed to provide for long-term, interim retrievable storage. Modern dry storage methods employ a mix of modular aluminum, steel, and/or concrete containment technologies to provide low-corrosion environments within sealed barriers. By using existing technology, dry storage concepts can be engineered to withstand severe conditions such as natural phenomena hazards, fires, and explosions without damage to the fuel or release of radionuclides. In addition, dry storage technologies can be adapted to store the many types of damaged and undamaged RINM that the Department owns. In general, assessments of dry storage technology indicate that its application results in fewer and less severe ES&H vulnerabilities. However, the Department has limited experience with aluminum-clad, damaged, and high enriched fuels in dry storage. A summary of the fuel and facility characteristics is provided in Attachment D.

• Dry Storage Facility Characteristics

RINM is stored dry in steel warehouses; lined and unlined concrete hot cells; steel-lined, concrete, below-grade vaults; reprocessing canyon dissolver cells; cans contained in steel wells; and large, above-grade storage casks.

Special dry storage facility characteristics include hot cells with argon or nitrogen cover gas, solid uranyl fluoride salt in a tank, and fuel in a can hanging from cable in a steel well. Dry storage facilities range from about 6 to 50 years in age. Only the newer facilities are designed specifically for monitored, interim, retrievable dry storage.

Dry storage facility confinement methods range from sealed canisters in wells surrounded by concrete, to extensive release protection, including HEPA-filtered ventilation systems.

Dry stored RINM is subject to monitoring programs ranging from periodic inspections to infrequent, or no inspections.

• Dry Storage RINM Characteristics

The actual condition of a significant amount of dry stored fuel is not known. However, much of this fuel resides within sealed containers, and in general, containers checked by the team were in good condition. Some instances exist where RINM in dry storage is uncharacterized. In some hot cell applications, hazardous material is co-located with RINM.

- **Dry Storage Issues and Vulnerabilities**

In several cases, RINM is being stored for the long term in dry storage facilities because there is no path forward for disposition. This has caused a backlog of RINM in several hot cells and other dry storage facilities. Storage of RINM on an open-ended basis has led to potential ES&H vulnerabilities:

- Some potential exists to release radioactive materials to the environment because of poor housekeeping practices (e.g., resulting in blocked drains, obstructed ventilation) that may compromise some aspects of the authorization basis. (See the related discussion of the Unreviewed Safety Question (USQ) in Hanford Pacific Northwest Laboratory Building 324 (PNL-324); and discussions of PNL-325, PNL-327, and ICPP Fuel Element Cutting Facility (FECF) in Chapter 2.)
- Institutional control failures can cause vulnerabilities that increase the potential worker exposure and radionuclide release. Hot cells and some dry storage facilities are shielded to provide a high degree of radiation protection. However, none of the facilities are authorized for long-term storage of RINM and some conditions and potential accidents have not been analyzed. (See the related discussion of PNL-324/325/327, ANL-W Hot Fuel Examination Facility (HFEF), and ZPPR in Chapter 2.)
- Some of this material has been stored for significant periods of time and in some cases does not undergo monitoring inspections. (See the related discussion of PNL-324/325/327, Oak Ridge Molten Salt Reactor Experiment (MSRE), HFEF, FECF, and General Atomics in Chapter 2.)
- Older dry storage facilities generally were not designed to protect against natural phenomena hazards. (See the related discussion of MSRE, and PNL 327 in Chapter 2.)
- Quantities of RINM may remain in dry storage facilities for much longer than originally contemplated. Barriers may severely corrode. Corrosion and the potential for release to the environment exist in several in-ground steel-lined storage wells. Due to the inaccessibility of these facilities for inspection, materials could be released to the environment without detection. (See the related discussion of ANL-W Radioactive Scrap and Waste Facility (RSWF) in Chapter 2.)

The above conditions and symptoms identified for dry storage led to a determination of adverse conditions, which in turn led to a determination of ES&H vulnerabilities. Dry storage facilities are characterized by adverse conditions associated predominantly with radioactive material release. Most vulnerabilities identified have impact on the workers and less so on the environment.

3. BURIED STORAGE

For purposes of this assessment, buried RINM refers to materials already buried, or to materials prepared for and awaiting burial. Due to the varying practices used over the years, the RINM may or may not be readily retrievable.

- **Buried Storage Facility Characteristics**

Facilities for burying RINM on location have been used since the inception of the various nuclear programs within the Department complex. Generally, these facilities consist of isolated, grade-level trenches with gravel, compressed soil, or asphalt pads on which the RINM is set prior to being covered with a soil overburden.

The two exceptions to this configuration within the scope of this study are (1) disposal wells at Oak Ridge, which were augured to a depth of 17 feet and capped with concrete plugs after they were filled with uranyl sulfate, and (2) the possible in situ burial of RINM sludge in the 105 F- and 105 H-Basins at the Hanford site. RINM stored in newer, interim buried storage facilities is packaged in retrievable sealed containers, including concrete casks, EBR-II casks, zircaloy hull containers, lead-lined concrete casks, and concrete-filled, 55-gallon drums.

- **Buried Storage RINM Characteristics**

Wide variation exists in the physical form and content of buried material at Departmental Sites. In many instances, specific records were not kept about the placement of irradiated materials in burial grounds. Materials located in burial grounds were often uncharacterized and details relative to their quantities and condition remain unknown.

- **Buried Storage Issues and Vulnerabilities**

Prior to the 1970s, isolated underground burial took place within the DOE complex to provide interim storage and, in some instances, to dispose of RINM. To a significant extent, material was buried without protective barriers or containers and without adequate records. These practices have ceased. However, the materials buried in the last two decades were never designed or intended to remain in place for prolonged periods prior to removal to permanent repositories.

Substantial quantities of buried RINM are now subject to corrosion and possible dispersion. This results from direct contact with the burial medium and groundwater immersion during periods of precipitation. In some instances, certified burial containers are nearing the ends of their design life without an identified disposition. The following vulnerabilities are considered to exist as a result:

- Because of uncertainties in the location, quantity, and nature of buried material, there may be potential for uncontrolled and undetected release of radioactive materials to the environment, as at the Oak Ridge Classified Burial Ground and the Hanford Inactive Burial Grounds.
- The release of radioactive materials to the soil has resulted from burial without containment, or the breach of containment, caused by corrosion of the container, as at the Oak Ridge Homogeneous Reactor Experiment (HRE) Wells.

- The use of unapproved containers for interim storage of RINM creates uncertainties about the potential for degradation and release to the environment. Also, the chance of accidental exposure of personnel involved in recovery operations could be increased (as at Hanford, P- and H-Reactors and the Oak Ridge burial grounds).
- Some potential exists to exceed the approved storage life of buried containers due to the lack of a path forward to disposition. This could result in the subsequent release of material to the environment and potential exposure of personnel involved in recovery operations at the Hanford 200 West Area Burial Grounds.

As a result of the above conditions and symptoms, buried RINM storage facilities are characterized by adverse conditions associated with the release of radionuclides, inadequate institutional controls, and the potential for worker exposure. The biggest impact of buried RINM storage is on the environment and on the health and safety of the workers who will remediate the burial sites.

4. SUMMARY OF VULNERABILITIES

The Working Group Assessment Team categorized the vulnerabilities identified through this assessment according to their potential impacts, and the urgency with which these impacts need to be addressed. A summary of related data for all sites and all facilities is displayed in Chart 2 and Chart 3.

Potential radionuclide release is the dominant adverse condition. Potential impact on worker safety and health is the dominant vulnerability. Potential for significant impact on public safety and health is much less likely. This is due to the remote locations of most storage facilities. In the judgment of the Working Group Assessment Teams about 50% of the vulnerabilities are sufficiently important to warrant inclusion in the most urgent category, namely those that warrant attention within the next 12 months. Box 4 summarizes general findings from the above discussions as well as from generic issues discussed below.

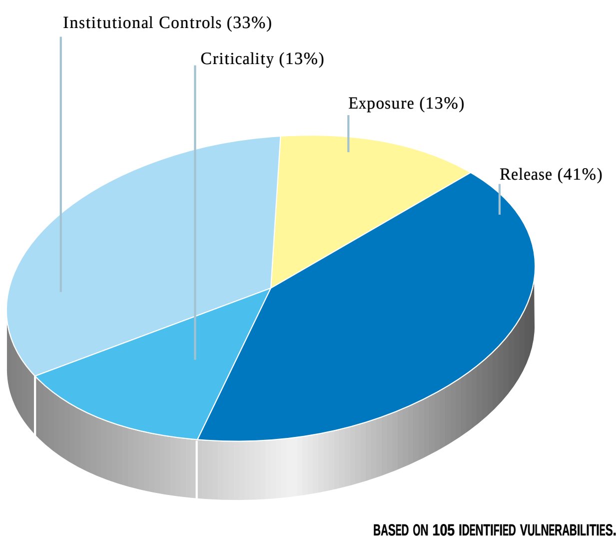


CHART 2 - SPENT FUEL ADVERSE CONDITIONS

BOX 4 - GENERAL FINDINGS

- The vulnerabilities identified predominately affect the workers and the environment; their potential for significant negative impact to public health and safety is much less likely.
- No conditions were found that required immediate action to prevent harm to the workers or the public.
- The predominant adverse condition identified is the actual or potential loss of barriers to the release of radioactive material.
- The safety analyses of many DOE facilities containing RINM neither accurately reflect the current condition of stored RINM nor analyze the hazards associated with its long-term storage.
- Many of the storage facilities and their RINM are vulnerable to earthquake damage.
- Some facilities contain RINM for which no DOE Program Office appears to have clear programmatic responsibility.
- The full characterization of much of DOE's RINM is unknown because of its degraded state or inaccessibility.
- The absence of a clear path forward to disposition RINM has complicated DOE's efforts to maintain safe interim storage.

C. GENERIC ISSUES

Common ES&H issues arose at many of the storage facilities. These issues should be considered when making decisions about near term plans to encapsulate or move RINM at the sites.

1. STORAGE AUTHORIZATION BASES

The Working Group Assessment Teams noted that the authorization bases for many storage facilities do not reflect the changed missions and aged conditions of the facilities. They also do not fully address worker safety and other issues now emphasized by the Department. Box 5 shows authorization bases elements.

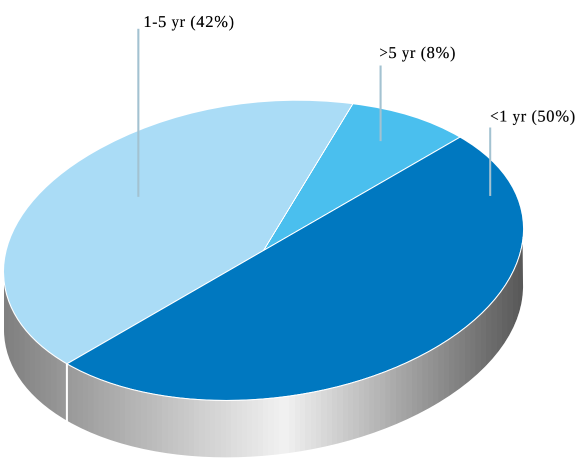
Several research and reprocessing facilities that are now shut down continue to store spent fuel, even though they have reduced operator staffs with limited inspection and maintenance. Degraded conditions due to aging and contamination continue to build.

The older authorization bases used for many facilities emphasized limiting risk to the public. Less emphasis was placed on analyzing risks to the workers and the environment. Potential accidents were not always analyzed rigorously because Department storage facilities are located in remote areas, and postulated worst-case scenarios were insufficient to expose the public to large quantities of radioactive materials.

BOX 5 - AUTHORIZATION BASES
- Safety Analysis
- Limiting Conditions for Operation
- Administrative Controls
- Facility-Specific Commitments
- Bases for Interim Operation

2. SEISMIC ISSUES

At a large number of the assessed storage facilities, earthquake design issues were identified. In many cases, the vulnerabilities arose from the fact that the older seismic designs do not meet today's more rigorous standards. In some cases, however, vulnerabilities such as unreinforced masonry walls, unqualified overhead cranes, and uphill boulders would not satisfy even the older standards. For example, seismic failures of unreinforced masonry walls pose threats to spent fuel storage at the SRS's Receiving Basin for Off-site Fuel (RBOF), INEL's Advanced Reactivity Measurement Facility (ARMF) and Coupled Fast Reactivity Measurement Facility (CFRMF), and West Valley's Fuel Receiving and Storage Facility. Moreover, the reduced structural integrity of corroded spent fuel and racks was not anticipated or evaluated in the original seismic analyses.



BASED ON 96 IDENTIFIED VULNERABILITIES. NINE VULNERABILITIES RELATED TO THE AUTHORIZATION BASIS OR PROGRAMMATIC ISSUES AND ARE NOT INCLUDED IN THIS CHART.

CHART 3 - SPENT FUEL VULNERABILITIES

3. PROGRAMMATIC OWNERSHIP

Some Department facilities contain RINM for which there appears to be no program or funding. Typically, this "orphan" material is left over after a program terminates with insufficient closeout funding to transport the material to a suitable storage facility or, alternatively, to ensure continued safe storage at its current location. Contractor overhead accounts or other active programs are relied upon to analyze and control the hazards associated with storing this RINM. ES&H vulnerabilities can arise if the funding for remaining active programs is insufficient to ensure continued institutional control (e.g., surveillance, maintenance, safety analyses) of the leftover material.

For example, termination of the program funds for operating the ARMF and CFRMF in INEL caused the complete loss of the operations staff. These two reactors were shut down and their cores were left in the reactor pool without removing the highly enriched fuel. The M&O contractor has continued to maintain the facilities out of an overhead fund, but cannot conduct operations necessary to move or remove the fuel.

PNL-324 and PNL-327 are other examples. When the program that funded the handling of Cesium-137 capsules ended, the contractor was left with 33 cesium capsules containing approximately 1 million curies to store.

4. MATERIAL CHARACTERIZATION

Many Department spent fuel storage facilities contain some fuel that is uncharacterized. Irradiated fuel rods manufactured from a wide variety of materials (e.g., metal alloys, carbides, oxides) were cut up and examined in hot cells and then stored in sealed cans. Fuel rods damaged in a reactor or during subsequent storage also have been canned and stored in both wet and dry storage facilities. Some irradiated nuclear material has been stored dry inside casks or other shielded containers and some has been buried. Most of these containers have not been opened in many years to analyze the condition of the material. Some fuel (both canned and uncanned) stored in pools is also not characterized to the degree necessary to determine future handling and disposition. Encapsulated RINM is difficult to inspect. Lastly, sludge in the bottom of some DOE wet storage facilities contains irradiated nuclear material of unknown concentration and composition.

This uncertainty complicates the Department's plans to provide safe, extended storage of RINM. The condition and composition of RINM may affect the design of future long-term storage containers and facilities. Moreover, some storage facilities contain hazardous constituents along with RINM, which may affect the applicability of environmental laws and regulations.

5. PATH FORWARD

As discussed earlier, the Department has stored most of its RINM far longer than originally intended. The absence of a clear path forward to disposition or otherwise provide long-term storage of this material is a generic issue complicating the Department's effort to provide safe interim storage. The Department has initiated both near- and long-term activities to address this problem including forming a dedicated organization, EM-37, in the Office of Environmental Restoration and Waste Management. Applicability of environmental laws, particularly the Resource Conservation and Recovery Act, is an important element of the path forward.

• NEAR-TERM PROGRAMS

At several facilities where existing storage conditions present significant ES&H vulnerabilities, the sites are planning actions to reduce or mitigate adverse conditions. The sites also plan to expand the storage capacity at selected facilities. This effort includes installing high-density storage racks (i.e., reracking) in storage pools at INEL and Savannah River. Reracking requires performing new analyses to ensure that new configurations are considered in all postulated accident scenarios. The sites are also considering encapsulating corroded fuel in other pools, or transferring RINM from degraded facilities to newer, less vulnerable facilities (both wet and dry). At the ICPP-603 FSF, where the existing storage conditions present significant ES&H vulnerabilities, the site plans to move RINM into ICPP-666 FSA, which is a more suitable storage facility. In addition, the INEL Site is redesigning dry storage wells at INEL and replacing them at ANL-W. However, the Working Group found that these plans were not mature or well coordinated. Site wide plans should be improved by recognizing the reality of constraints such as the unavailability of suitable qualified shipping casks and commitments to state governments.

- LONG-TERM PROGRAMS

The Department has initiated a programmatic Environmental Impact Statement (EIS) addressing complex-wide storage of all RINM. The EIS will evaluate various alternative plans for safely storing RINM until the year 2035. The Department plans to complete the final EIS by April 30, 1995, and issue a Record of Decision by June 1, 1995.

D. FACILITIES WITH MOST SIGNIFICANT VULNERABILITIES

Vulnerabilities associated with some facilities were evaluated as much higher than others. The facilities identified for discussion in this section exhibited the greatest vulnerabilities according to the following criteria:

- Inventory: The quantity of RINM in residence in the facility at the time of the review.
- Barriers to Release: The condition of the barriers that prevent the release of RINM, and actual or potential migration of RINM. Examples of these barriers include the cladding and the canisters containing the RINM, the surrounding medium, and the facility barrier that contains the medium. Mechanisms that cause failures in these barriers include corrosion, ineffective cleanup systems, pool leakage, and lack of facility ventilation and confinement.
- Uncertain Conditions: Those conditions where lack of information or knowledge creates difficulties in establishing the appropriate corrective actions, or would complicate the corrective actions. Examples of uncertainties are lack of knowledge about the exact location of buried RINM, the status of its migration, the condition of the containments, the characterization of the RINM, and the identification of its final disposition.
- Design: The original design of the facility is inadequate when compared to the current requirements or use of the facility.

Based on these criteria, the following RINM storage facilities were selected for priority attention.

1. 105-K EAST BASIN

This unlined concrete pool was built at Hanford in 1951, and contains the largest inventory of RINM in wet storage in the DOE complex. The damaged and corroded RINM stored in the pool continues to release fissile and other radioactive materials to the pool water, presenting a radiation hazard to workers, Photo 2.

2 - CORRODED N-REACTOR FUEL STORED IN OPEN CANISTERS, 105-K EAST BASIN, HANFORD SITE

3 - Corroded Reactor Target Slugs, Bucket I-14, L-Reactor Disassembly Basin, Savannah River Site

Following a recent back-flush of the pool water filter, it was discovered that the quantity of plutonium in the backwash pit exceeded administrative limits. Documented episodes in which radioactively contaminated water leaked from the pool to the environment pose additional concerns. Generic concerns include the lack of precise detail as to the material condition of some of the RINM in storage, the lack of modern earthquake-resistant features, and the fact that the facility was not designed for long-term storage. The site plans to encapsulate degraded spent fuel to prevent further release of fissile and other radioactive material into the basin. The encapsulation plan warrants management attention to ensure that the dose to workers is minimized and that contingencies are reviewed.

2. L-AND K-REACTOR DISASSEMBLY BASINS

These unlined concrete pools were built at the Savannah River Site in the mid 1950s, and each of them contains a substantial inventory of RINM in wet storage. The corroded RINM stored in each pool continues to release fissile and other radioactive materials into the pool water. Ground water monitoring wells outside the basin show elevated tritium levels, Photo 3.

The quantity of fissile material accumulating in the pool filtration system has not been identified as a current problem. However, the inability of the installed pool cleanup system to maintain cesium levels below current administrative limits is an issue, as are the lack of modern earthquake-resistant features, the lack of a negative-pressure-filtered ventilation system, and the fact that the facilities were not designed for long-term wet storage. The site plans to vacuum the sludge in the basins and take steps to retard the corrosion rate. The site plans to place the L-Basin targets in closed boxes inside the basin to contain insoluble radioactive material and other components of the sludge. The boxes will neither prevent continued corrosion of the RINM nor contain the soluble radioactive material. Difficulty is being encountered in maintaining radionuclides in the L-Basin pool below administrative limits.

3. ICPP-603 FSF

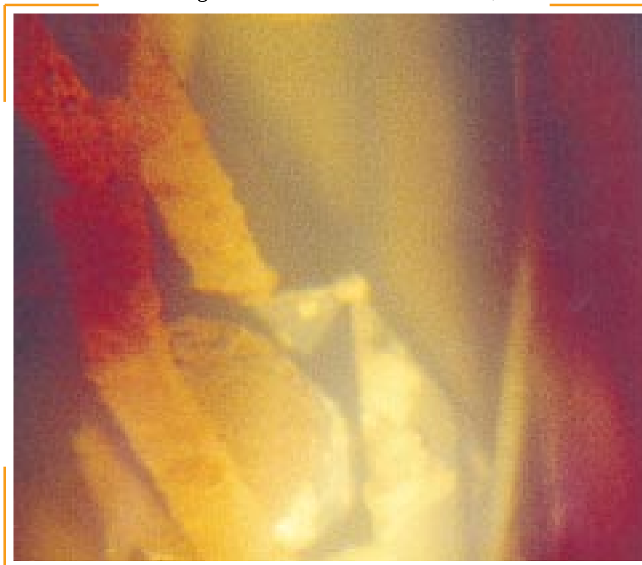
This facility contains a 1950s-vintage, unlined concrete pool with a substantial, diverse inventory of RINM in wet storage. Corrosion of vertical support structures and spacers installed between fuel elements to prevent nuclear criticality is severe. Fissile and other radioactive materials released to the pool are highly evident and present a radiation hazard to workers. Some RINM has fallen from its supporting equipment as this equipment corroded and created geometry changes that increase uncertainty in criticality margins, Photo 4. Generic issues include the lack of modern earthquake-resistant features, the lack of precise detail as to the material condition of some of the nuclear material in storage, the lack of a negative pressure filtered ventilation system, and the fact that the facility was not designed for long-term storage of RINM. The site has initiated a program to encapsulate degraded RINM and transfer the contents of this pool to a modern pool at the site. This program requires continued management vigilance.

4. PUREX

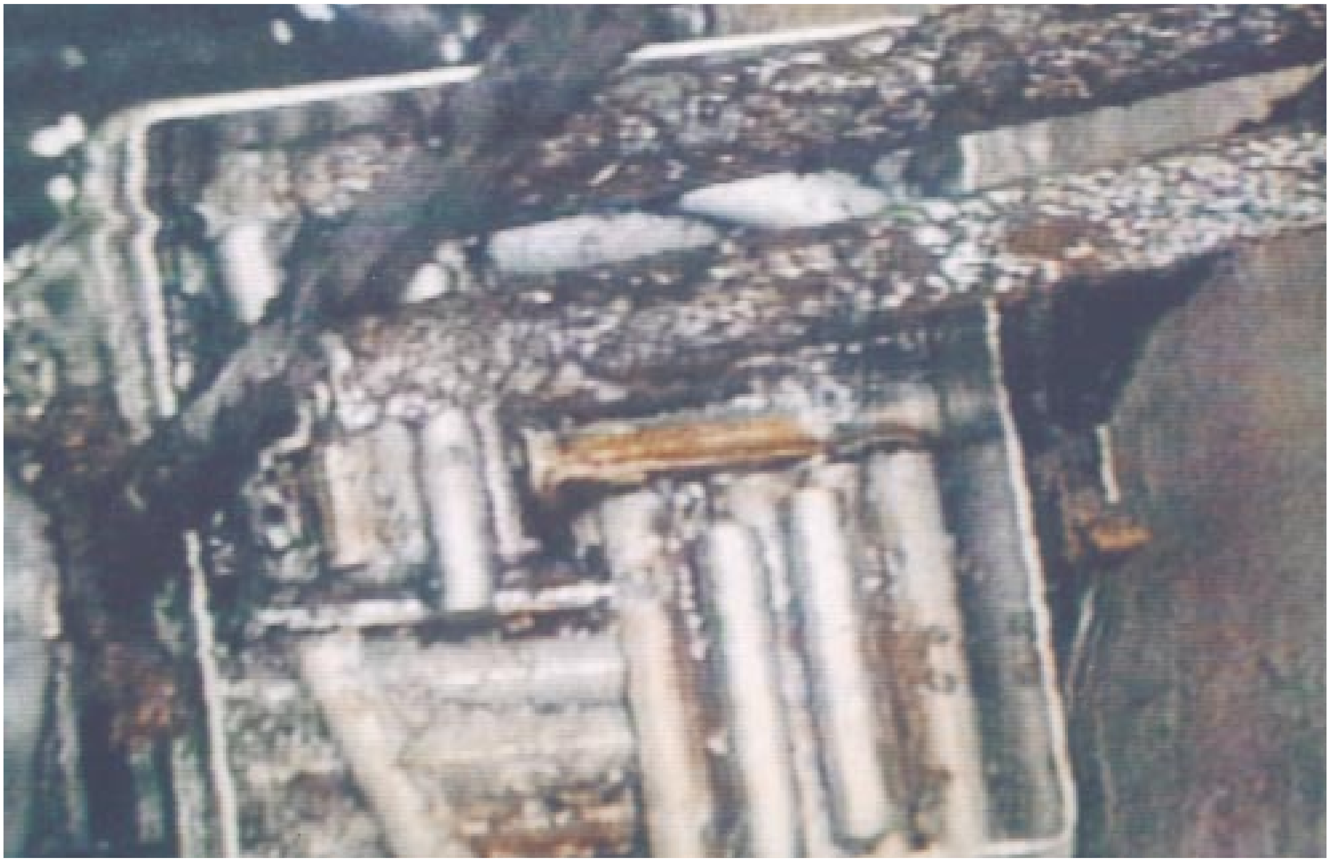
Current PUREX plant deactivation plans include retrieving and repackaging the Single Pass Reactor fuel elements in the slug storage basin and N-Reactor fuel elements on the dissolver cell floor for shipment to the 105-K Basins. The impact of shipment to 105-K Basins may need to be reconsidered in light of plans for those basins.

Due to the high radiation levels and the generally hazardous conditions in the PUREX canyon, access to inspect or monitor the fuel is very limited. If nothing is done to prevent or mitigate continued fuel corrosion or failure, remediation personnel will have to deal with increased fissile and other radioactive material releases.

According to PUREX personnel, the Single Pass Reactor fuel baskets in the slug storage basin can safely be moved only once more. The yoke assembly supporting each fuel basket is suspended from the basin ledge only at one end and is bent and severely corroded. If the fuel baskets were to fall, the contents of a fuel basket could spill onto the basin floor, further complicating remediation efforts. Management attention is warranted, Photo 5.



4 - Corroded Fuel Hanger, ICPP-603 Underwater Fuel Storage Facility (FSF), Idaho National Engineering Laboratory Site



5 - Corroded Single Pass Reactor Fuel and Yoke Assembly, PUREX Basin, Hanford Site

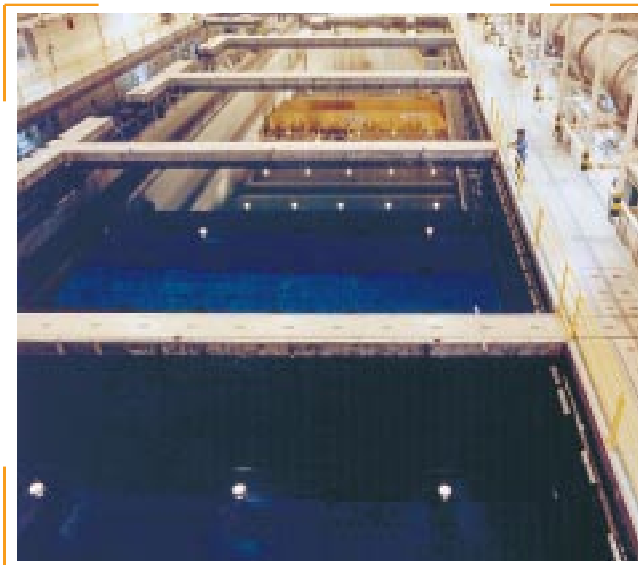
The uncertainty in the disposition path, the inability to prevent or monitor continued corrosion, and the potential for other complications involving the fuel at PUREX amount to a significant vulnerability.

5. BURIAL SITES

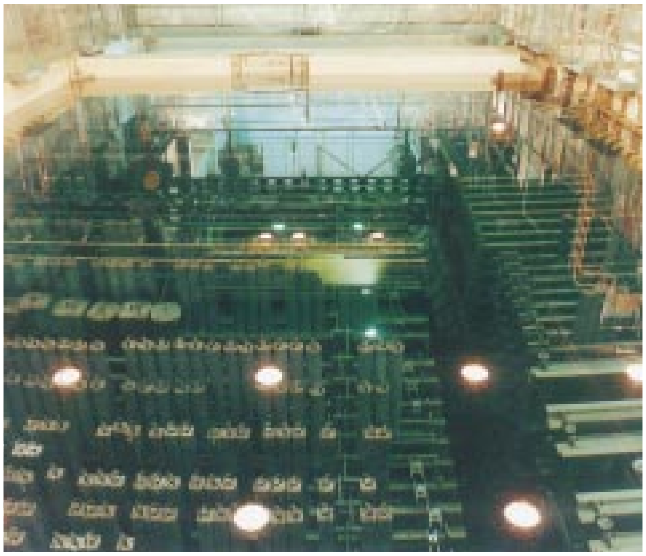
Potential adverse conditions involving the burial of RINM make this practice a vulnerability at the Hanford and Oak Ridge sites. Potential adverse conditions include (1) uncertainties associated with the exact location or nature of some of the buried materials, (2) release of radioactive materials to the soil as a result of burial without containment or breach of containment due to corrosion, (3) use of unapproved containers for interim storage of RINM, and (4) the potential to exceed the approved storage life of buried containers due to the lack of a path forward for disposition.

- Hanford 200 West Area Burial Grounds
  RINM is located in containers in trenches, some of which have been backfilled with earth. The integrity of some containers is unknown, and others are approaching their approved design life.
- Oak Ridge Classified Burial Ground
  An unknown quantity of RINM was buried somewhere in a 10-acre section of the burial ground. The exact location is unknown.
- Oak Ridge HRE Disposal Wells

In 1964, 135 gallons of spent fuel solution was poured into 17-foot-deep holes drilled in the earth. The holes were filled with dirt and marked by a concrete plug and brass plaque. Actions could be taken to determine the extent of radionuclide migration from these holes.



6 - ICPP-666 Underwater Fuel Storage Facility, Idaho National Engineering Laboratory Site



7 - RECEIVING BASIN FOR OFF-SITE FUEL, SAVANNAH RIVER SITE

E. BETTER FACILITIES: ONLY MINOR VULNERABILITIES

This section discusses some of the Department's better storage facilities. Some have stored RINM for extended periods of time without significant degradation or vulnerabilities. These facilities span the different types of storage technologies: new, old, wet, and dry.

1. ICPP-666 FSA

Constructed in 1984, this Idaho facility is the Department's newest wet storage facility, and most closely adheres to today's codes and standards for long-term storage. The facility design incorporates many of the features missing in older facilities. For example, it is seismically qualified and has an engineered leak-detection system. Unlike some of the facilities that were not designed for extended storage, the ICPP-666 FSA facility is equipped with the control systems necessary to maintain excellent water chemistry. No cases of RINM corrosion, were identified, nor were vulnerabilities identified, Photo 6.

2. RBOF

This Savannah River facility is an example of the successful operation of an older wet facility (vintage 1963) that stores RINM for extended periods. There are concerns about leak detection, and seismic and other natural phenomena hazard issues. The overall quality of design and facility management have ensured safe storage of aluminum-clad RINM in the basin for over 10 years. The concrete walls are coated with a phenoline paint, and the basin has a stainless-steel floor. These features, combined with a control system that maintains excellent water quality, create a good storage environment, Photo 7.

3. HFIR

This Oak Ridge facility is an example of successful operation and storage of aluminum-clad RINM associated with an operating reactor facility. The storage pool is located within the same primary confinement area, next to the reactor pool that contains the reactor vessel. Thus, the storage pool benefits from the reactor safety analyses and design features: ventilation and natural phenomena hazard protection. The above-ground construction of the pool and outer wall accessibility lessen the significance of the fact that the pool does not have a dedicated leak-detection system. Although the facility has not been analyzed for adherence to the new seismic criterion—ground acceleration of 0.2 g—it has been seismically qualified to 0.15 g. Like the ICPP-666 FSA, the HFIR storage pool is lined with stainless steel and has excellent water chemistry control. RINM has been stored in the basin for 7 years with no signs of significant corrosion, Photo 8.

4. ICPP UNDERGROUND STORAGE FACILITY (ICPP-749)

The second-generation dry storage vaults at this Idaho Underground Dry Vault Storage Facility are the best examples of DOE dry storage technology. Designed to correct deficiencies identified in the first-generation vaults within the same facility, the second-generation design is an all-metal vault encased in grout. This design guards against the introduction of moisture and permits purging and sampling of the dry vault interior for environmental control and indications of storage integrity loss, Photo 9.

8 - HIGH-FLUX ISOTOPE REACTOR BASIN, OAK RIDGE SITE

1.6 FINDINGS AND CONCLUSIONS

The previous section identified generic and facility-specific findings and conclusions that should be addressed in action plans to improve the safety of RINM storage. A summary of these is presented in text Boxes 2 and 4.

There should be a continued effort to improve our inventory information for RINM storage.

No facilities or burial grounds were found to require immediate action to prevent harm to the workers or the public. However, the five facilities and three burial grounds identified as having the most significant vulnerabilities warrant priority attention to ensure that the safety and health of the workers is protected, and actions are taken to protect the environment. The vulnerabilities that cause concern for the safety and health of the workers at these facilities increase with time, as does the potential for release to the environment.

The five generic issues identified in the previous section should be addressed during future spent fuel storage program decision making. The facility-specific vulnerabilities identified should be considered facility-specific action plans.

This chapter of the report presented the overall results of the Spent Fuel Working Group evaluation to identify the facilities and issues that were found to warrant special attention by the Department. Chapter 2 presents a description of the facilities at each site and the vulnerabilities that were identified. This chapter is intended to briefly summarize the reports of the Working Group Assessment Teams that are contained in Volume II.

9 - ICPP-749 Underground Storage Facility, Idaho National Engineering Laboratory Site

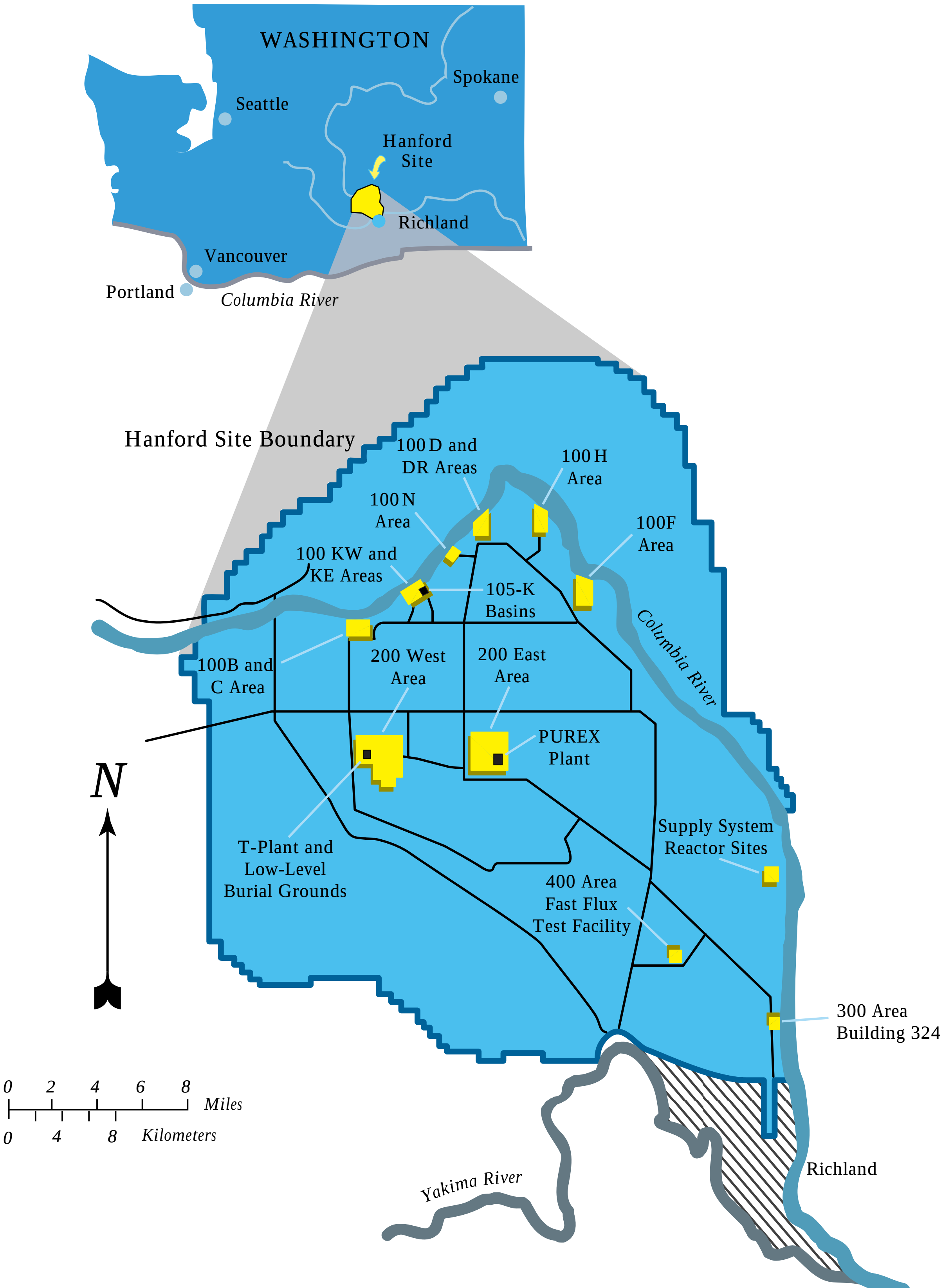


Figure 3 - Hanford Site Map

2 - Summaries of Working Group Assessment Team Reports

Summaries of the Working Group Assessment Team Reports are provided in Sections 2.1 through 2.11 of this chapter. Sections 2.12 through 2.18 contain summaries of information received from sites not visited. Volume II contains the complete reports.

2.1 HANFORD SITE

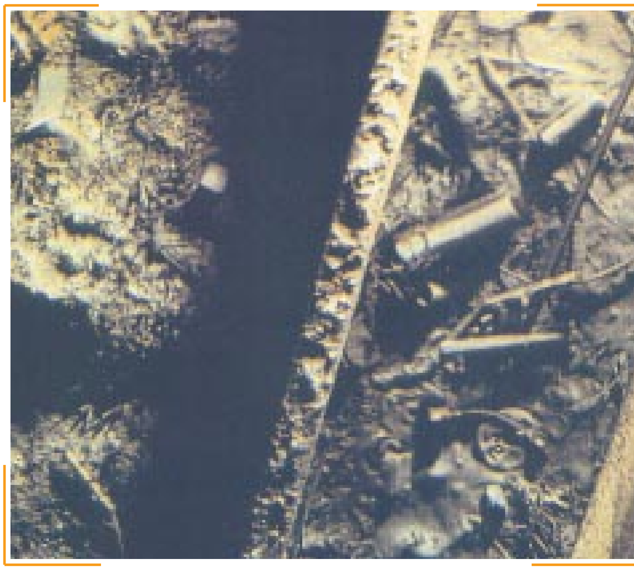
The Hanford Site contains ten individual fuel storage facilities or fuel storage locations. Spent fuel stored at Hanford includes both wet and dry storage configurations. The locations of fuel storage facilities vary from those in close proximity to the Columbia River (300 Area, 105-K East and 105-K West Basins) to those in the 200 Area plateau 10 to 15 miles from the river (PUREX, 200 West Area Burial Grounds, T-Plant, FFTF), Figure 3.

A. 105-K EAST BASIN

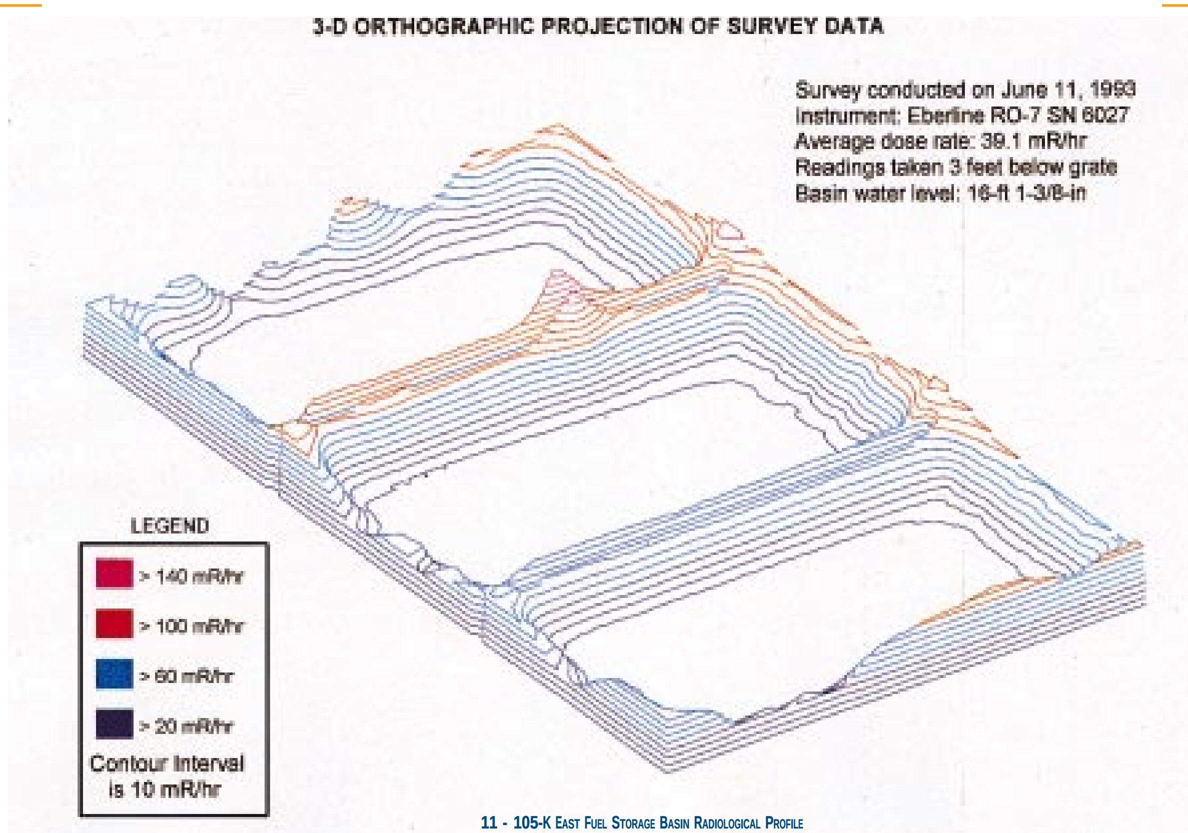
The 105-K East Basin was designed for interim storage (up to 20 years) of irradiated fuel and consists of an unlined concrete water pool with an asphaltic membrane under it. The facility contains N-Reactor and Single Pass Reactor fuel.

Current plans call for fuel encapsulation with possible consolidation of 105-K East Basin fuel inventory into the 105-K West Basin. Sludge containment is planned. The Hanford EIS, which is currently not funded, will result in a record of decision for final disposition of the N-Reactor fuel. The EIS alternatives include wet and dry storage systems. The revised Notice of Intent (NOI) for the Hanford EIS was delayed pending issuance of the INEL EIS implementation plan issued on October 29, 1993.

It is estimated that the cladding on more than 50% of the fuel in the 105-K East Basin has failed. This has resulted in radioactive material releases to the pool water. Sludge accumulation in the pool in some locations is estimated to be greater than 14 inches, Photo 10. Additionally, the 105-K East Basin has leaked twice, releasing tritium and other radioactive materials to the environment. Monitoring wells in the vicinity of the basin show increases in tritium. Levels are beginning to approach the drinking water limit for tritium of 20,000 pico-curies/liter. The K-30 monitoring well has exceeded this limit. The proximity of the basin to the Columbia River represents an additional environ-



10 - Sludge and Miscellaneous Items, Bottom of 105-K East Basin, Hanford Site



11 - 105-K East Fuel Storage Basin Radiological Profile

mental vulnerability. Vulnerabilities associated with radioactive material release include increased exposure of workers, and increased risk of release to the environment, Photo 11.

Institutional control failures may cause ES&H vulnerabilities, as may the seismic inadequacy of the pool. Recently, excessive plutonium accumulation in the sand filter backwash pit resulted in a positive USQ. The pit was a modification to the existing pool to facilitate filter backwash. Urgent issues involve completion of analyses concerning exceeding the limits for plutonium in the sand filter backwash pit and a plan for commencing encapsulation. An efficient method of encapsulation may be needed to avoid additional radionuclide release to the pool and attendant worker exposures, Photo 12.

B. 105-K WEST BASIN

The 105-K West Basin was designed similarly to 105-K East. However, this basin is in much better condition because it is epoxy coated and its fuel is encapsulated. The facility contains N-Reactor and Single Pass Reactor fuel. Current plans include possible consolidation of fuel from the 105-K East Basin and/or PUREX. Fuel will be held in the 105-K West Basin pending decisions on disposition.

Because the fuel has already been encapsulated, many of the vulnerabilities identified in the 105-K East Basin have been avoided. Vulnerabilities at 105-K West Basin include the seismic inadequacy of the pool, institutional controls (e.g., authorization bases, procedures, and administrative controls), tritium in monitoring wells, and uncharacterized fuel stored in encapsulated canisters, Photo 13.

C. PACIFIC NORTHWEST LABORATORY BUILDING 324

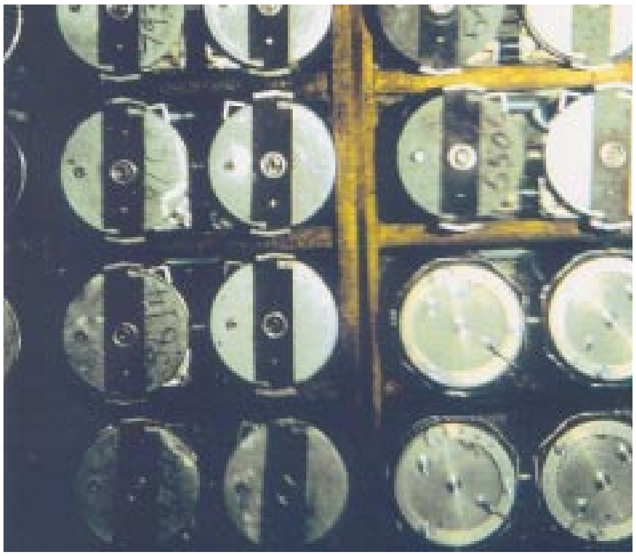
PNL-324 is a chemical processing laboratory, that is also used for examination and mechanical testing of irradiated fuel specimens. It houses four stainless-steel-lined hot cells (A, B, C, & D) in the Radiochemical Engineering Cells area and two hot cells (East and South) in the Shielded Material Facility. Currently, light water reactor fuel is stored in the A- through D-Cells.

Vulnerabilities include significant quantities of radioactive material in dispersible forms and institutional control problems which have resulted in a USQ concerning blockage of the pathway to the hot cell drains. Funding and conduct of operations issues are the institutional control problems that may continue to cause vulnerabilities. The facility lacks an updated and approved safety analysis report. Although the hot cells provide an acceptable temporary storage location, a plan is needed for ultimate disposition of fuel. Additionally, remediation efforts should continue to remove the dispersible quantities of radioactive materials from the B-Cell. Management attention also appears to be warranted in the area of housekeeping.

D. PACIFIC NORTHWEST LABORATORY BUILDING 325

PNL-325 is the Radiochemical Facility and Shielded Analytical Laboratory. This houses nine stainless-steel-lined hot cells (three in the radiochemical facility and six in the laboratory) used to conduct radiochemical research and waste tank characterization. Currently FFTF, EBR-II fuel, and light water reactor fuel pins are being stored on an interim basis in B-Cell and in the Shielded Analytical Laboratory cells.

12 - FUEL AND FUEL STORAGE CANISTERS, 105-K EAST BASIN, HANFORD SITE



13 - Sealed Fuel Storage Canisters, 105-K West Basin, Hanford Site

The facility does not have an updated and approved facility safety analysis report. Although the hot cells provide an acceptable temporary storage location, a pathway for ultimate disposition of fuel has not yet been developed. Management attention also appears to be warranted in the areas of housekeeping and funding.

E. PACIFIC NORTHWEST LABORATORY BUILDING 327

PNL-327 is the Post-Irradiation Testing Laboratory that houses 11 high-density iron- or steel-lined hot cells, two interconnected water basins, and a dry storage cell used for physical and metallurgical examination and testing. Currently, FFTF fuel, light water reactor fuel pins, and miscellaneous test reactor fuel pins are being stored on an interim basis in the hot cells, the pool, and a dry storage cell.

PNL-327 has accumulated a significant quantity of radioactive material in the hot cell ventilation ducts. It also has the vulnerabilities associated with RINM backlog, housekeeping, and the authorization basis described above for PNL-324 and PNL-325. This radioactive material buildup represents a radiation exposure hazard to the workers. Accessible areas of the basement of PNL-327 have radiation level readings as high as 10 R/hr. Contributing to this radioactive material buildup is the fact that the radioactive liquid waste system is isolated in PNL-327, a facility with no hold tank capacity, and thus limited in its ability to decontaminate hot cells. With isolated canyon floor drains, environmental release is also possible. Finally, a minor vulnerability exists since the seismic analysis for PNL-327 is not completed. This analysis is in progress. Characterization of the radioactive material buildup in the ducts is currently scheduled for FY 94; however, no funding exists for the cleanup of the ducts. Management attention appears to be warranted in the areas of housekeeping and funding.

F. FAST FLUX TEST FACILITY (FFTF)

The FFTF is a liquid-sodium-cooled nuclear reactor capable of operating at power levels up to 400 MW. The facility is DOE's newest and highest-power test reactor. The facility was constructed to test fuels and materials for the liquid metal reactor program. In April 1992, DOE placed the FFTF in a hot standby condition. A decision is pending on its future mission. With the exception of two Fuel Pin Shipping/Storage Containers in the Interim Examination and Maintenance Cell, all irradiated elements are currently stored under sodium. Current plans call for placing the fuel in dry interim storage pending final disposition, if the decision is made to shut down the FFTF.

G. 308 BUILDING ANNEX

The 308 Building Annex houses the Neutron Radiography Facility and the TRIGA reactor. The TRIGA reactor was used as a source of neutrons in neutron radiography and for training of nuclear operators from N-Reactor and from the Washington Public Power Supply System. The facilities were operational from the late 1970s until May 1989. The reactor has been defueled, and the reactor pool is providing storage for 101 irradiated and 3 unirradiated fuel assemblies. Current plans call for interim storage of the fuel for 2 years, followed by movement to dry storage casks that are being designed.

Two vulnerabilities were identified that involve fuel storage at TRIGA. The first arises from the current facility plans to eliminate technical safety requirements and operational safety requirements, since the facility is no longer an operating reactor. Continuing to maintain institutional and safety basis controls on pool operations would help to minimize degradation of fuel in the facility. A less significant vulnerability arises from the lack of programmatic support for removing the stored fuel and placing it in dry storage casks pending final disposition.

H. T-PLANT

The T-Plant complex was constructed in the mid-1940s to extract plutonium from spent nuclear fuel using the bismuth phosphate process. In 1957, T-Plant was converted to a beta-gamma decontamination facility. Decontamination activities in the canyon were suspended about 2 years ago. The main facility in T-Plant is the 221-T Canyon Building, which contains 37 cells and one railroad tunnel entrance and exit. One of the cells adjacent to the railroad tunnel is 13 feet wide by 27.5 feet long by 28 feet deep. It was modified to serve as a spent fuel pool for storage of Shippingport Pressurized Water Reactor Core II irradiated fuel. There are currently no plans for disposition of the fuel located at T-Plant.

Four vulnerabilities were identified at T-Plant. The most serious stem from the seismic susceptibility of the fuel pool that has a long hairline crack in it, the lack of an approved path forward for disposition of the fuel, and the need for improved housekeeping. Seismic analyses predict substantial pool wall cracking as a result of moderate earthquakes (e.g., 0.1g). A leaking hairline crack running from top to bottom of one wall exacerbates this vulnerability. However, the pool water is not heavily contaminated and the leak flows into the canyon. A minor concern is also created by the cooling water system pumps that are operating in a damp environment.

14 - Damaged and Corroded N-Reactor Fuel Element, Bottom of PUREX Dissolver Cells, Hanford Site

I. PUREX

The PUREX Canyon Building 202-A was constructed in the early 1950s to recover uranium and plutonium from irradiated nuclear fuels discharged from the Single Pass Reactors and N-Reactor. The storage basin was designed for once-through cooling with untreated discharge. Currently, Single Pass Reactor fuel is stored in an unlined concrete pool located at the east end of the building. In addition, fuel is stored in three process (dissolver) cells having floors and walls constructed of reinforced concrete. Spilled fuel is lying on the floor of the cells in an air environment. PUREX is shut down and about to undergo transition to long term minimum surveillance activities. Plans to package and transfer fuel to 105-K East or 105-K West Basins are being considered, although no clear direction exists for this effort.

Five vulnerabilities were identified in the PUREX plant, ranging from the current condition of fuel stored in corroded baskets to the method in which the fuel is examined and inspected. The latest photo inspection in 1991 indicated significant damage to fuel cladding and radioactive material release, Photo 14.

Fuel is stored in fuel baskets which are suspended by corroded, bent, and poorly supported yoke assemblies. Pool water is not treated and is infrequently sampled. Level monitoring is verified only quarterly. In addition, corroded fuel lying on the bottom of the dissolver cells creates a significant vulnerability for remediation workers.

J. BURIAL GROUNDS

The 200 West Area Burial Grounds provide for retrievable interim storage of RINM and transuranic waste. Area 218W-3A is a series of trenches with a V-shaped gravel bottom. Area 218W-4C is a series of trenches with a flat asphalt bottom. FFTF, TRIGA, light water reactor, and miscellaneous test reactor fuels are stored in these trenches in sealed containers of the following types: concrete casks, EBR-II casks, zircaloy hull container, or lead-lined concrete-filled 55-gallon drums. Thirty-five EBR-II casks are stored above ground; the others have been backfilled with gravel. Current plans call for retrieval of RINM and placement in the Waste Isolation Pilot Plant (WIPP) or in the final geologic repository.

Vulnerabilities arise from exceeding the design life of the storage containers currently used, failing to provide an authorization basis for non-EBR-II casks, exceeding the design life of the analyzed storage casks, and inappropriately classifying fuels currently being placed in the burial grounds. The Working Group Assessment Team also concluded that an accurate inventory of fuel buried at Hanford does not exist, which could result in additional hazards to remediation workers and the environment. Fuel was identified during the visit in several other areas of the Hanford site, including the 618 Burial Grounds (inactive) and the 200 Area inactive burial grounds.

2.2 IDAHO NATIONAL ENGINEERING LABORATORY SITE

The Idaho National Engineering Laboratory (INEL) is a multi-program laboratory operated by seven major contractors under the direction of two Department of Energy Offices, Idaho and Chicago, and the Pittsburgh Naval Reactors Office. INEL sits on 890 square miles of desert in southeastern Idaho 45 miles west of Idaho Falls, Figure 4.

Since 1949, a total of 52 reactors have been built at the INEL site. Spent fuels from these reactors have been managed onsite. In addition, INEL has received offsite spent fuel from more than 30 sources including university reactors, commercial reactors, and DOE research reactors, as well as U.S.-fabricated fuels from foreign reactors. Spent fuel is currently stored in various dry and wet storage facilities in five areas of INEL.

A. IDAHO CHEMICAL PROCESSING PLANT (ICPP)

The ICPP facilities, operated by the Westinghouse Idaho Nuclear Company, contain the bulk of the site's spent fuel. In 1953, ICPP began processing spent nuclear fuel to recover highly enriched uranium. The main purpose of the ICPP was to receive spent naval nuclear fuel, develop fuel reprocessing and other fuel

15 - ICCP-603 Underwater Fuel Storage Facility, Idaho National Engineering Laboratory Site

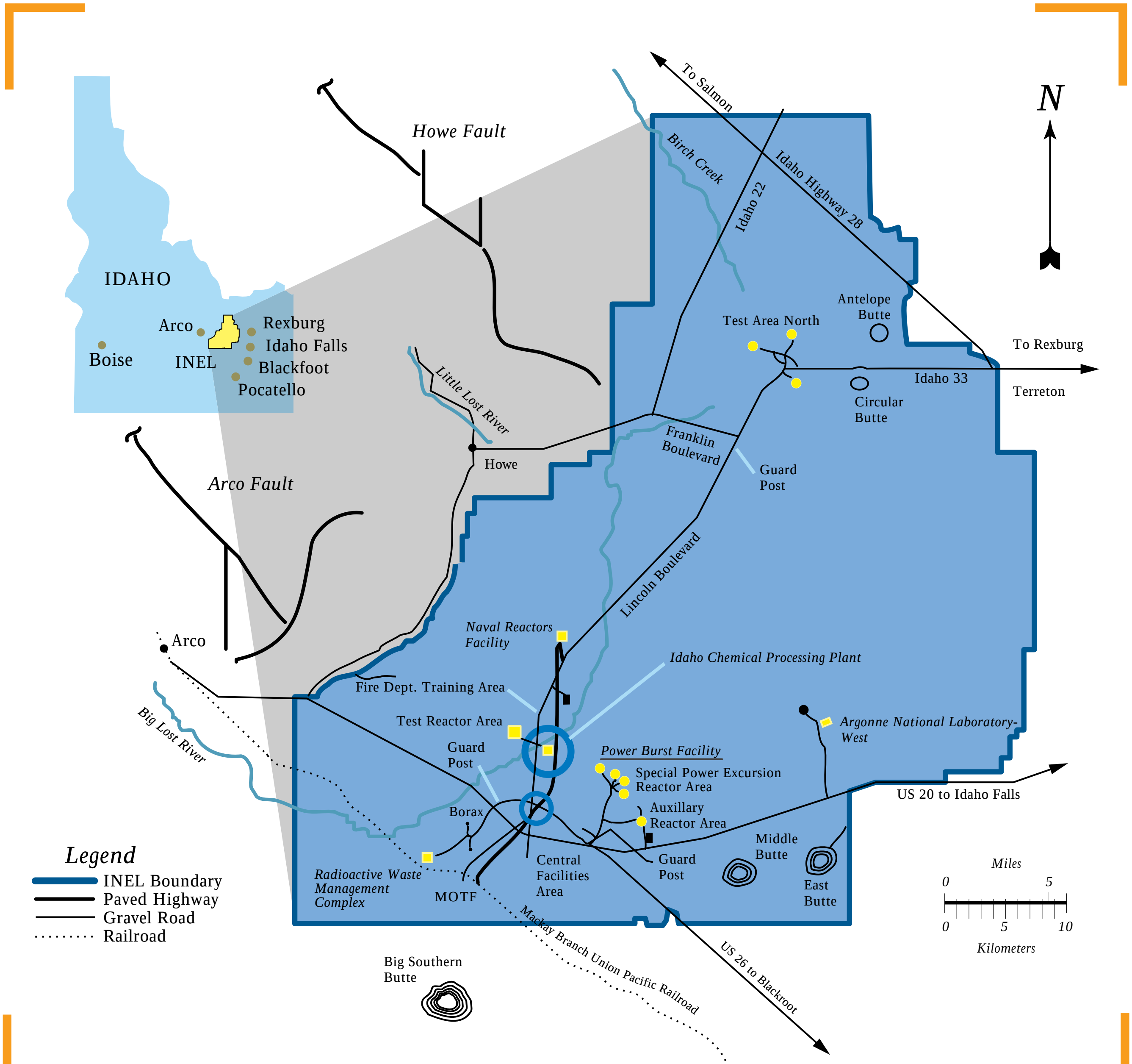


Figure 4 - Idaho National Engineering Laboratory Site

dispositioning methods, and manage associated high-level waste. In 1992, the DOE decided to cease reprocessing operations at the ICPP. The ICPP contains five facilities for spent fuel storage: the ICPP-603 Underwater Fuel Storage Facility (FSF), the ICPP-603 Irradiated Fuel Storage Facility (IFSF), the ICPP-666 Underwater Fuel Storage Area (FSA), the ICPP-749 Underground Storage Facility, and the ICPP-603 Fuel Element Cutting Facility (FECF).

1. ICPP-603 UNDERWATER FUEL STORAGE FACILITY (FSF)

The ICPP-603 FSF consists of three unlined concrete pools—north, middle, and south basins. The north and middle basins were built in 1951 and the south basin was added in 1959. The FSF is loaded to about 52% capacity, and 23% of the positions are currently considered unusable because of corrosion. Spent fuels stored here include those from naval reactors, the Advanced Test Reactor, the High Flux Beam Reactor, the Oak Ridge Reactor, and EBR-II, Photo 15.

Largely because of its age and past operating practices, the ICPP-603 FSF has a number of deficiencies. The spent fuel, aluminum storage structures, and the carbon steel storage yokes and buckets have severely corroded over time. The pools are unlined. Radionuclides have diffused into the pools' concrete walls and there is limited capability to monitor the pools for potential leakage. Seismic evaluations have shown that there are weak areas in the storage facility superstructure, resulting in some potential for loss of confinement, release of radioactive materials, and decreased margins for preventing criticality. Finally, the facility does not

16 - ICCP-603 IRRADIATED FUEL STORAGE FACILITY,
IDAHO NATIONAL ENGINEERING LABORATORY SITE

have a ventilation system for radionuclide confinement. Plans are to phase out spent fuel storage at the ICPP-603 FSF storage pools by expediting removal of fuels so that the facility can be shut down by the year 2005.

2. ICPP-603 IRRADIATED FUEL STORAGE FACILITY (IFSF)

Built in 1974, the ICPP-603 IFSF is composed of shielded dry vaults for storage of graphite fuels. It was designed to meet interim fuel storage requirements prior to reprocessing or final disposition, and to provide safe dry storage wells for fuels. The spent fuel is stored in 636 carbon steel canisters, which are approximately 18 inches in diameter and 11 feet long. Decay heat is removed by a forced-flow ventilation system. Currently, spent fuel stored in the IFSF is mainly from two commercial reactors, Fort Saint Vrain and Peach Bottom; and from the ROVER Nuclear Rocket Program. The assessment team noted that a potential fire hazard may exist because a few graphite fuel assemblies are stored in cardboard fuel containers inside this facility and the ventilation system for maintaining cooling appears to be unreliable, Photo 16.

3. ICPP-666 UNDERWATER FUEL STORAGE AREA (FSA)

ICPP-666 is a modern underwater fuel storage facility that began operation in 1984. It is a stainless-steel-lined fuel storage basin that closely adheres to current design requirements. Fuels stored are from Naval reactors, the Advanced Test Reactor, the High Flux Beam Reactor, EBR-II, and the Fermi Blanket. The facility is currently 46% full. Reracking using taller racks is being considered to increase the storage capacity for receiving fuel from ICPP-603 by the year 2002. No vulnerabilities were identified for this facility. However, the assessment team noted that contemplated fuel movements of degraded aluminum clad fuels from the ICPP-603 FSF to the ICPP-666 FSA could lead to contamination of the ICPP-666 complex if they are not properly controlled.

4. ICPP-749 UNDERGROUND STORAGE FACILITY

ICPP-749 consists of 218 underground dry vaults, built between 1971 and 1987. One hundred twenty-eight of the 218 dry vaults contain fuel from Peach Bottom Core I and the Fermi Blanket in aluminum canisters. The carbon steel liners of the 61 first generation vaults have undergone significant corrosion due to seepage of moisture. Fifty-nine of these vaults contain fuel in aluminum canisters. Some of these canisters have been inspected and show moderate corrosion. Gas samples show some canisters may be breached but there is no current indication of failed fuel clad. Although water that collects in these vaults may leak to ground, the water samples taken to date show no fission products present. Current plans are to move this fuel into second generation vaults during fiscal years 1994 to 1996. Funding for this activity has been authorized. The second generation vaults are of an improved design that (unlike the first-generation design) provides a cathodically-protected all-metal storage container enclosed in grout. The dry wells do have some deficiencies: routine visual inspection of the storage canisters in the wells is very complicated, and it is difficult to ensure that radioactive material leakage is not occurring. In addition, the dry well design offers limited confinement capabilities, given that it must be opened during fuel handling.

A significant hazard associated with the first generation wells is the potential for carbide-water reactions. If the fuel is damaged and water is allowed to contact it, the carbide-bearing fuels could react exothermically with water to produce acetylene and oxygen. Acetylene together with oxygen could form an explosive mixture.

5. ICPP-603 FUEL ELEMENT CUTTING FACILITY (FECF)

The purpose of the ICPP-603 FECF is to prepare incoming fuel for subsequent rack storage in the ICPP-603 FSF south basin. This facility has not been used since the mid 1960s, except for temporary storage of miscellaneous fuels. The facility contains two Peach Bottom fuel elements. An underwater canal provides access to the ICPP-603 FECF from the ICPP-603 FSF south basin.

The lights inside the cell have not been operable for 6 years. The material condition of the two fuel elements, which have not been inspected for 10 years, is unknown. The failure to inspect and develop a path forward for fuel disposition represents an institutional failure.

B. TEST REACTOR AREA (TRA)

The primary mission of the TRA is the operation of the Advanced Test Reactor used to study the effects of radiation on materials. The TRA has spent fuel largely stored at three locations. These are the TRA-603 Materials Test Reactor (TRA-603 MTR), the TRA-660 Advanced Reactivity Measurement Facility (ARMF) and the Coupled Fast Reactivity Measurement Facility (CFRMF), and the TRA-670 Advanced Test Reactor (ATR).

1. TRA-603 MATERIALS TEST REACTOR (MTR)

The TRA-603 MTR stores spent fuel in a stainless-steel-lined canal located in the basement of the reactor building. The MTR canal is an older facility designed to support the MTR operating mission. After completing the MTR mission, the canal was used as an experimental handling and working facility for Power Burst Facility (PBF) support. The canal was used as a test, inspection, and assembly area for the PBF Severe Fuel Damage Test Program. Products of the damaged-fuel experiments are stored in the canal.

Most of the fuel elements are encapsulated in stainless steel or aluminum tubes and are placed in aluminum canisters. Minor corrosion was visually noted on the top of the canisters. The canisters are randomly inspected on a semi-annual basis, to verify their location and condition. Periodic maintenance is done routinely on electronic equipment that monitors for criticality.

The facility design (i.e., canal cleanup, seismic design, ventilation, leak detection, monitoring, and chemistry control) neither supports nor was intended for long-term fuel storage. Although it is stainless-steel-lined, the canal does not have a leak detection system. There is no programmatic ownership for this facility. In addition, the facility is not adequately funded for upgrades, analysis, and/or documentation update.

2. TRA-660 ADVANCED REACTIVITY MEASUREMENT FACILITY (ARMF) AND COUPLED FAST REACTIVITY MEASUREMENT FACILITY (CFRMF)

TRA-660 ARMF and the CFRMF reactors, along with the neutron radiography facility, share a single canal. The roof is composed of steel deck, the walls are 8-inch hollow concrete block, and the floor is reinforced concrete. The facilities are swimming pool reactors with light water moderated cores consisting of plate-type fuel elements containing high enriched uranium.

The water in the pool is relatively clear with some visible algal growth. The fuel elements seemed to be in good condition without any visible corrosion. The radionuclide content of the pool is insignificant because the facilities were operated at low power levels and the fuel does not contain appreciable fission products. The water chemistry is periodically monitored and corrected, as necessary. The facility is not designed to support long-term fuel storage. It lacks leak detection and water cleanup systems.

Presently, preventive maintenance and surveillance activities by the M&O contractor are being performed with limited overhead funds and staff. Because these facilities have no active programs or funding, the facility has no qualified operating personnel that can manipulate the fuel that is currently in the reactors. For similar reasons, no program office oversight was observed. In fiscal year 1995, the facility is scheduled for deactivation, which will require removing the high enriched uranium, and aluminum clad fuel from the two cores.

3. TRA-670 ADVANCED TEST REACTOR (ATR)

The ATR, a light-water cooled and moderated test reactor built in the 1960s, creates a reactor environment to study the effects of radiation on materials and fuels. The ATR Facility contains a working and storage canal, a transfer canal, and a critical facility canal, all of which are connected with inflatable seals and separation bulkheads. The reactor is fueled with high enriched uranium elements in an aluminum assembly. After an element has reached its end of life, it is stored in the canal until the decay heat has diminished to a level that allows shipment to the ICPP.

The canal system contains space for cask storage, irradiated hardware, fuel element storage racks, an underwater saw and saw table, and other storage. The canal is stainless-steel-lined with a built-in leak detection system to detect any leakage behind the steel liner. The canal will be fully utilized as long as the ATR is in operation. The ATR program is projected to end by the year 2014. There were no vulnerabilities identified with this facility.

C. TRA-620 POWER BURST FACILITY (PBF)

The PBF consists of a reactor and a canal that has a deep section to provide shielding for cask loading and for routine operations on the in-pile tube that holds test specimens in the PBF core. The PBF driver core, composed of 2,415 stainless-steel-clad uranium dioxide and zircaloy fuel pins, is stored in various-sized canisters within two fuel storage racks in the PBF canal. The canal has a liner with stainless steel bottom welded to painted carbon steel sides. It is equipped with a leak detection system, and has been shown to meet seismic code. The only vulnerability identified for this facility is that corrosion monitoring is inadequate. In 1992, the facility was placed in operational shut down. Plans are to remove fuel by fiscal year 1996.

D. TEST AREA NORTH (TAN)

At the TAN, two areas are used for storage of spent nuclear fuel: the TAN-607 Pool and the TAN-607 Cask Storage Pad. The TAN-607 Hot Shop (THS) can be used to support spent fuel packaging and handling activities. However, the THS facility is currently not operational and will require a restart review before it can support any SNF activities.

1. TAN-607 POOL

The TAN-607 water pool is loaded to about 100% of usable capacity (i.e., loading limit) with Three Mile Island-Unit 2 core debris canisters, commercial fuel, and other materials, Photo 17.

The TAN-607 pool and supporting facilities were constructed in the 1950s. The pool is unlined and does not comply with leak detection and control requirements specified for new, stainless-

17 - TAN-607 Water Pit Pool, Idaho National Engineering Laboratory Site

18 - TAN-607 Cask Storage Pad, Idaho National Engineering Laboratory Site

steel-lined, concrete pools. The positive pressure ventilation system at this facility is inappropriate for preventing airborne radioactive material release to the environment. The current planning projects the start of decommissioning in about 10 years. A vulnerability was identified with respect to the seismic inadequacy of the pool.

2. TAN-607 CASK STORAGE PAD

The TAN-607 Cask Storage Pad was constructed in 1985 as part of the Spent Fuel Cask Testing Project. Five casks are presently located on the pad. The fuel in these casks can only be transported within the TAN area. Transporting the fuel requires unloading it from the storage cask and placing it in a transport cask using the THS facility. The total contents of these casks are 24 consolidated fuel canisters and 39 PWR fuel assemblies. No vulnerabilities were identified at this facility, Photo 18.

E. ARGONNE NATIONAL LABORATORY WEST (ANL-W)

ANL-W operates the Experimental Breeder Reactor II, the Hot Fuel Examination Facility, the Radioactive Scrap and Waste Facility, the Zero Power Physics Reactor, the Transient Reactor Test Facility, and the Neutron Radiography Reactor. These facilities have been used largely for advanced reactor systems research.

1. EXPERIMENTAL BREEDER REACTOR II (EBR-II)

EBR-II is the only power-producing, liquid-metal-cooled, fast-spectrum reactor in the country. Present operating plans are to discharge about 50 spent fuel subassemblies per year, with reactor operations continuing through the year 1996. EBR-II also has about 330 depleted-uranium blanket subassemblies that are discharged as they reach their neutron-fluence-determined end of life. In addition, many experimental fuels have been and are being irradiated in EBR-II as part of a variety of experimental programs.

No ES&H vulnerabilities were identified at this facility. According to its present mission, the EBR-II spent fuel will be reprocessed in the Fuel Cycle Facility (presently unfunded) for reuse in the EBR-II reactor. However, the onsite storage space to accommodate the entire EBR-II spent fuel inventory is expected to be adequate. A safety analysis to confirm this determination is ongoing.

2. HOT FUEL EXAMINATION FACILITY (HFEF)

The HFEF is a large, two-room hot cell facility with a range of fuel examination capabilities. About 90 intact subassemblies from EBR-II are presently stored in the argon gas atmosphere of the HFEF. Active cooling is required in those areas set aside for high-decay-power subassemblies. The Working Group Assessment Team did not identify any significant ES&H vulnerabilities.

3. RADIOACTIVE SCRAP AND WASTE FACILITY (RSWF)

The RSWF consists of a rectangular array of about 1,200 vertical, steel-lined dry storage wells in the ground. About 700 of the wells house a wide variety of radioactive scrap and wastes, using a wide variety of packaging schemes. The occupied wells are seal-welded closed. Presently, about 1,000 EBR-II fuel elements and 500 blanket elements are in the RSWF. Active cooling is not required in the RSWF. The RSWF is in the process of being upgraded by installing new liners that have cathodic protection, and repackaging the contents of some of these wells, Photo 19.

According to the site personnel, the fuels inside the containers are stainless-steel-clad and are not breached. However, the existence of severely corroded storage wells coupled with the lack

19 - Corroded Canisters, ANL-W Radioactive Scrap and Waste Facility, Idaho National Engineering Laboratory Site

of a monitoring program for soil contamination was identified as a potential vulnerability.

4. ZERO POWER PHYSICS REACTOR (ZPPR)

The ZPPR is a split-table critical assembly that has been placed in non-operational standby status. The facility has fuel stored in an adjacent vault. The ZPPR fuel is clad in stainless steel. Most of the fuel is a plutonium-depleted uranium-molybdenum alloy, although there are some enriched-uranium metal, uranium oxide, and mixed uranium-plutonium oxide fuels. Metal fuel is in the form of small plates. Oxide fuel is in the form of small rods. Fuel is stored in canisters, and the canisters are placed in openings in concrete blocks. Active cooling is not required. The ZPPR fuel is unique in that there is almost no fuel burnup and thus it has a low fission product inventory.

The team noted one minor vulnerability. A vulnerability exists for fission product release because the uranium has oxidized and hydrided on approximately 25% of the plates, causing stainless steel cladding to bulge. In a few isolated cases, the cladding is breached. The future mission of the ZPPR is uncertain.

5. TRANSIENT REACTOR TEST FACILITY (TREAT)

The TREAT reactor is a uranium-oxide-fueled, graphite-moderated, air-cooled reactor designed to produce short, controlled bursts of neutrons. It was designed to simulate accident conditions leading to fuel damage, including melting or even vaporization of test specimens, without damaging the reactor. It contains 360 zirconium fuel elements, made of graphite with enriched uranium oxide particles dispersed throughout the graphite matrix. TREAT has 446 dry storage wells in the floor, each of which accommodates one fuel element. TREAT is a pulsed reactor. Therefore its fuel has very low burnup and a correspondingly low fission product inventory. There were no vulnerabilities identified for this facility.

6. NEUTRON RADIOGRAPHY REACTOR (NRAD)

The NRAD reactor, a TRIGA-type reactor located within the HFEF, is used for neutron radiography of a variety of samples, mostly irradiated fuel. There is some storage capacity for fuel elements in the reactor tank outside the core. Additional storage locations would need to be identified if all fuel were to be removed from the reactor tank. There were no vulnerabilities identified.

2.3 SAVANNAH RIVER SITE

The Savannah River Site has eight facilities that contain RINM, Figure 5. The facilities include both wet and dry storage systems. Most of the RINM stored is in wet storage.

Current DOE program guidance identifies chemical separation processing as the defined mission for disposition of the RINM at Savannah River; however processing has been delayed to address the associated safety and environmental issues.

Corrosion of fuel elements and reactor targets in wet storage basins and the subsequent release of radioactive materials to the basin environment constitute the major ES&H vulnerabilities. Most of the problem areas are associated with production reactor fuel and targets stored in K- and L- Reactor basins. The Receiving Basin for Off-Site Fuel (RBOF) is in good condition, even though some material has been stored for 30 years.

A. L-REACTOR DISASSEMBLY BASIN

The L-Reactor began operations in the mid 1950s. The fuel and targets from this reactor were originally intended to be housed in the Disassembly Basin for an interim period of 12 to 18 months. The Disassembly Basin is an epoxy-coated concrete pool with no accurate leak detection or high-efficiency ventilation systems. Because of recent delays in the production fuel cycle, some reactor irradiated nuclear material has been stored for 5 years or more.

Aluminum clad fuel is suspended vertically on stainless steel hangers and is corroded severely at the aluminum-to-stainless steel interface, Photo 20. Aluminum clad, reactor irradiated targets, which are stored in stainless steel buckets, are also corroding. Due to the limited capacity of the pool water deionizers, the basin radioactivity content is approaching an administrative limit.

20 - Dummy Fuel Tube, Vertical Storage, L-Reactor Disassembly Basin, Savannah River Site

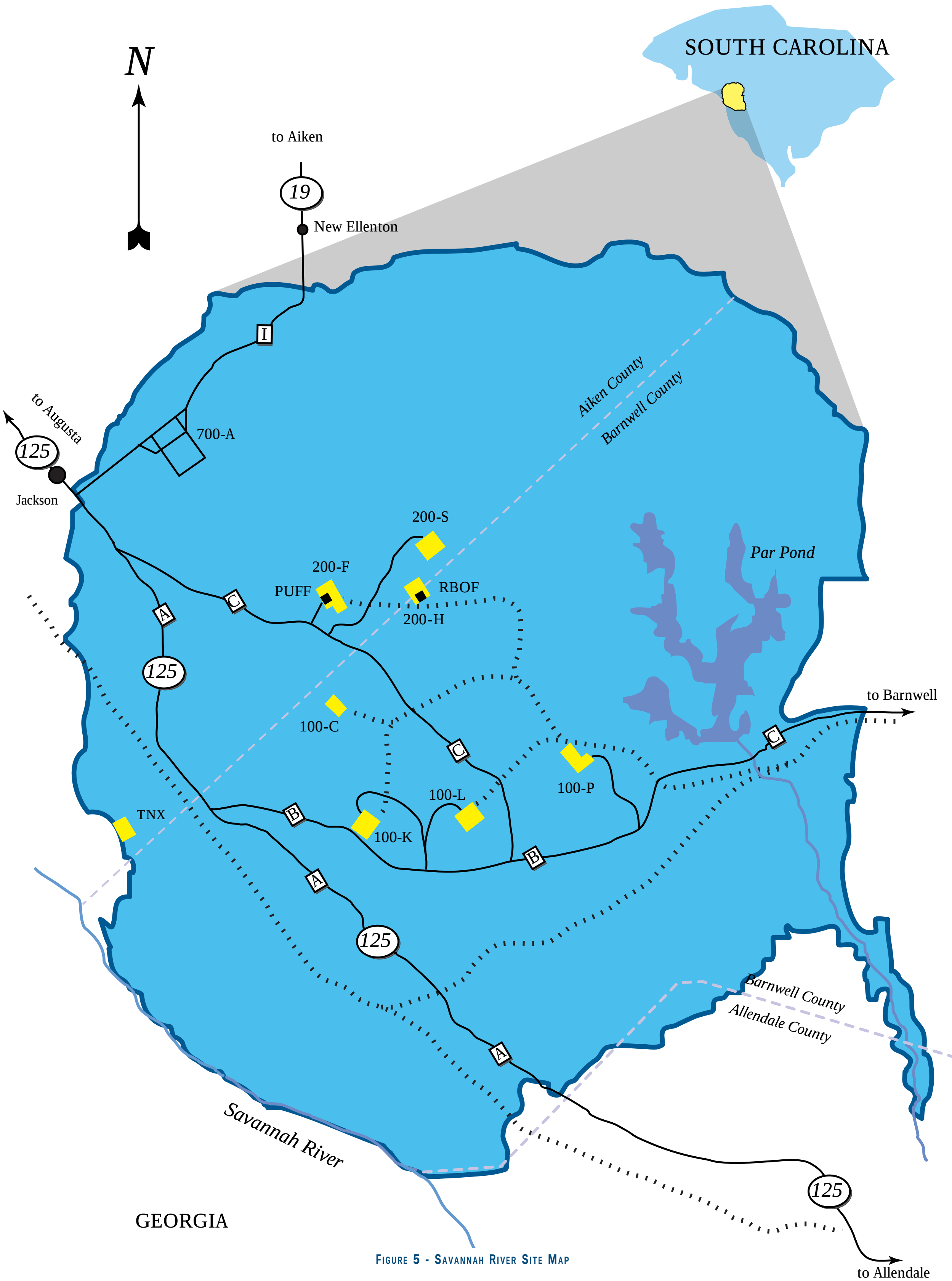


Figure 5 - Savannah River Site Map

The accumulation of highly mobile sludge (i.e., iron, aluminum, and silicon) on the floor of the basin contributes to the ionic impurity of the pool water and, thereby, to the continued corrosion. The transport of fissile materials through the aluminum cladding into the basin, and their subsequent deposition and concentration in sludge and water filtration components (e.g., sand-filters and deionizers), result in questions concerning concentration of fissile material and nuclear criticality.

Actions are being taken to improve water quality by vacuuming sludge and obtaining additional water purification capabilities. Nuclear criticality evaluations have been performed in connection with the sludge vacuuming operation.

The Basin is not designed to current seismic design criteria. Hence, natural phenomena hazards, such as earthquakes, raise issues concerning the potential for releases of radioactive materials to the environment and margins for preventing nuclear criticality.

B. K-REACTOR DISASSEMBLY BASIN

The K-Reactor began operations in the mid 1950s. As with the L-Reactor Disassembly Basin, the storage of reactor fuel and reactor irradiated targets was originally intended for an interim period of 12-18 months. The Disassembly Basin is an unlined vinyl-coated concrete pool with no accurate leak detection or high-efficiency ventilation systems. Because of recent delays in the production fuel cycle, some reactor irradiated nuclear material has been in storage for 5 years or more.

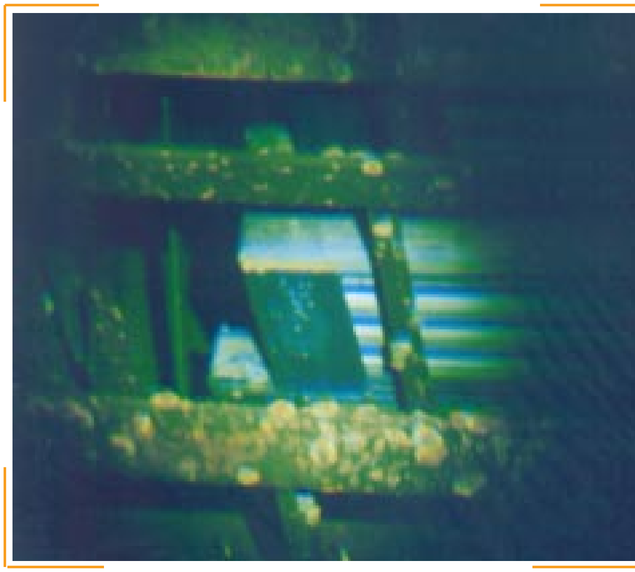
Adverse water chemistry control issues and resultant corrosion problems in the K-Reactor Disassembly Basin are similar to those discussed for the L-Reactor Disassembly Basin. Sludge removal is also planned for the K-Reactor Disassembly Basin.

C. P-REACTOR DISASSEMBLY BASIN

The P-Reactor began operations in the mid 1950s. At the time of the assessment, all of the issues associated with corrosion, radioactive material release to the pool water, and sludge were found to apply to the P-Reactor Disassembly Basin, Photo 21.

D. H-CANYON STORAGE BASIN

The storage basin is located in a remotely operated, shielded area of the H-Canyon Building, where chemical separations processing from production reactors is conducted. RINM in the form of 13 reactor fuel assemblies packaged in five storage bundles is housed in a water-filled, stainless-steel-lined concrete basin. The basin normally serves as an interim staging location for reactor fuel bundles awaiting chemical separations processing in the H-Canyon. No excessive corrosion of the fuel element bundles was detected during recent remote video camera inspections. However, the existence of high ionic impurities in the basin water, the lack of installed mechanisms for the control of water chemistry in the basin, and the past resident time in the reactor disassembly basins provide conditions conducive to corrosion. Nevertheless, the potential consequences associated with releases of radioactive material to basin water and postulated events such as criticality are mitigated by the shielded location of the basin and the fact that the area is not occupied by personnel.



21 - Fuel Assembly Tube Bundle, Horizontal Storage, P-Reactor Disassembly Basin, Savannah River Site

E. F-CANYON STORAGE BASIN

Several stainless-steel buckets containing aluminum-clad reactor irradiated targets are housed in the F-Canyon storage basin. The F-Canyon basin, like the H-Canyon basin discussed above, is located in a remotely operated, shielded area and provides a staging location for targets awaiting processing through the F-Canyon chemical separations process.

The F-Canyon storage basin is made of concrete and is unlined. However, two stainless-steel storage racks sit in the bottom of the basin. The "bath tub" storage racks hold the water as well as the buckets.

As at the H-Canyon, no provision exists for the maintenance of water chemistry. Untreated, unfiltered potable water is added as necessary to restore water level. Chemical analysis shows that ionic impurities in the water are conducive to corrosion of the aluminum-clad targets. A resultant release of radioactive material to the basin water would be mitigated by the shielded location of the basin and the fact that the area is not occupied by personnel.

F. RECEIVING BASIN FOR OFF-SITE FUEL (RBOF)

The RBOF receives and stores reactor fuel elements primarily from offsite reactors and occasionally from onsite reactors. The RBOF is a concrete pool with a stainless-steel bottom and painted sides that went into operation in 1963. The original design incorporated a basin water chemistry control system consisting of a filter and mixed ion-exchange system. The fuel elements in the RBOF, some of which have been in the basin for 30 years, show no visible signs of corrosion.

All fuel assemblies stored at the RBOF facility are housed in aluminum canisters and placed in egg crate type storage racks that provide the spacing required to preclude nuclear criticality.

Potential vulnerabilities identified were limited to lack of up-to-date safety documentation and the lack of a leak detection system. Despite the good quality of its construction and maintenance, the facility has features that would not be found in current designs. Masonry walls above the disassembly, inspection, and repackaging basins could damage the irradiated fuel in the pool should a seismic event cause the walls to collapse. The unhardened roof creates a similar potential for damage, in the event of tornado missiles. In addition, storage racks, although anchored to the floor and wall of the basin, are not seismically qualified.

G. BUILDING 773A

Building 773A is a hot-cell facility with the capability of destructively examining highly irradiated nuclear materials. This facility contains four partial sections of fuel material stored in a dry configuration since 1987. No vulnerabilities were identified at this facility.

H. BUILDING 331M

Building 331M is a steel warehouse structure that houses the uranium fuel elements discharged from the 305-M test reactor pile in dry storage. No vulnerabilities were identified at this facility.

2.4 OAK RIDGE SITE

The Oak Ridge Site contains 13 facilities housing spent fuel.

A. BUILDING 3019 – RADIOCHEMICAL DEVELOPMENT FACILITY (RDF)

The RDF was built in 1943 and contains secure storage wells, hood and glovebox laboratories, shielded remote processing cells, and shielded hot cells. Originally, the facility was intended to support radiochemical processing development; but, since 1963, the RDF has served as the national repository for U-233. The fuel is contained in dry wells and plans call for its continued storage there. No vulnerabilities were identified.

B. BUILDING 3525 – IRRADIATED FUELS EXAMINATION LABORATORY

Constructed in 1963, the Irradiated Fuels Examination Laboratory is a two-story, brick structure, which contains hot cells. Disassembly and examination of irradiated fuel and components continue to be the mission of the facility. Current work in the facility is limited. However, new program missions are currently being investigated. No vulnerabilities were identified.

C. BUILDING 4501 – HIGH LEVEL RADIOCHEMICAL LABORATORY

The High Level Radiochemical Laboratory was constructed in 1951. It contains centrally located hot cells supported by various laboratories capable of handling radioactive material. The facility was designed to perform experimental studies on radioactive materials. Most recently, it has been used in performing work for the Nuclear Regulatory Commission on fission gas release in light water reactor fuel rods. The spent fuel is in dry storage. No vulnerabilities were identified.

D. BUILDING 7920 – RADIOCHEMICAL ENGINEERING DEVELOPMENT CENTER (REDC)

The REDC is a multipurpose hot cell facility with the appropriate equipment, shielding, and containment provisions to safely process and store large quantities of highly radioactive fuel elements. The facility was specifically built to prepare and process targets for the HFIR. The RINM is in dry storage. No vulnerabilities were identified.

E. BUILDING 7930 – RADIOCHEMICAL ENGINEERING DEVELOPMENT CENTER

This facility is a heavily shielded hot cell facility constructed between 1964 and 1967 designed for remote operation using master-slave manipulators. Its mission was to develop and demonstrate methods for remote processing of irradiated-thorium-based fuel and to fabricate the recovered materials into fuel suitable for reuse in a power reactor. Currently, the facility is involved in the Californium (Cf-252) Industrial Sales/Loan Program. The Cf-252 is now in dry storage. No vulnerabilities were identified.

F. BUILDING 9201-5-Y-12

This facility is a large warehouse containing numerous vaults for storing and safeguarding highly enriched uranium. It is distinguished by its high level of security. Current operations consist of transfers, storage, and an inventory of uranium in containers of various types. All the RINM is either very low burn-up or unirradiated material. The material is in dry storage. No vulnerabilities were identified.

G. BULK SHIELDING REACTOR (BSR)

Built in 1951, this pool-type research reactor is currently shut down with the core stored in racks. Fuel assemblies from the Oak Ridge Research Reactor are also stored in the pool. Pool water quality is controlled. Seventy-three of 90 storage locations are occupied. No vulnerabilities were identified.

H. HIGH FLUX ISOTOPE REACTOR (HFIR)

The HFIR is an 85-MW, beryllium-reflected, light-water-moderated, flux-trap-type research reactor with associated support equipment and a storage pool. Missions include production of isotopes for medical and industrial applications, neutron-scattering experiments, and various material irradiation experiments. Current plans are to continue reactor operation. No vulnerabilities were identified, Photo 22.

I. MOLTEN SALT REACTOR EXPERIMENT (MSRE)

Built in the mid 1960s, the MSRE is an 8-MW, homogeneous reactor consisting of uranium fluoride fuel in molten lithium salt. Before it was shut down, the purpose of the reactor was to test the practicality of a molten-salt reactor concept for central power station applications. Now in shutdown status, the fuel is stored in the salt storage tanks beneath the reactor.

Radioactive material migration has been detected from the storage tanks. This vulnerability could result in unnecessary personnel exposure. If left unabated, radiation levels could increase to a point where access would be difficult. ORNL is actively pursuing resolution of this issue.

J. TOWER SHIELDING REACTOR (TSR)

The TSR is a reactor facility where experiments were conducted outdoors on a remote hilltop. It is a spherically symmetric 1-MW plate-type TSR-II reactor. Currently, it is in shutdown status with no future plans for use. The facility has four 315-foot-high towers erected on the corners of a rectangle 100 feet by 200 feet. The purpose of the facility was to conduct large-scale experiments to test shielding design methods and obtain associated data. The original TSR-II core is located in the reactor. Four fuel plates are

22 - High-Flux Isotope Reactor, Oak Ridge Site

stored in the underground site, and 1,200 low enriched fuel pins are stored in Department of Transportation shipping containers.

A postulated collapse of the steel truss tower structure due to earthquakes or high wind loads could dislodge lead shielding on the reactor building beam port and result in high radiation levels outside of the reactor facility. Although this is a low probability event, it could lead to unnecessary personnel exposure during recovery operations. Interim actions are to place shielding blocks in an array to protect the lead shields on the reactor building port.

K. 7823A/7827/7829 WELLS

Currently closed to further storage, these shielded, retrievable storage facilities are stainless-steel dry wells placed in the ground in Solid Waste Storage Area (SWSA) 5 North. They vary from 8 inches to 30 inches in diameter and 10 feet to 15 feet deep. Surrounded by dirt, the wells are placed on a concrete pad and are held in place by concrete collars or concrete slabs. Used to store irradiated fuel and associated fission products, the wells were filled from 1972 to 1989. A potential vulnerability exists because irradiated fuel and associated fission products could be released to the environment if corrosion breaches the wells. Funds are available to remove this material from the wells once an above-ground storage is completed in late 1990s.

L. HOMOGENEOUS REACTOR EXPERIMENT (HRE) WELLS

Seven augured holes were drilled in 1964, 1 foot in diameter and 17 feet deep, and placed approximately 10 feet apart. After 135 gallons of a 4-molar fuel solution was poured into the holes, each well was filled to ground level with soil and marked by a concrete plug and a brass plaque. Monitoring data from wells installed in the early 1980s have not detected migration of this material.

The vulnerability associated with the wells is the fact that irradiated fuel and associated fission products have been released to the environment. Further activities to monitor the spread of contamination may be warranted due to the distance to the existing monitoring wells.

M. CLASSIFIED BURIAL GROUND

This area is now closed to operations. In the past, RINM from classified programs was buried in the area. The exact quantity and location of all of this buried material are not known. Currently, ORNL is seeking records to determine the originator of the material and to obtain any additional information.

A vulnerability results from the fact that uranium of unknown quantity has been placed in unknown locations in the burial ground. This creates a potential hazard to the environment and to remediation workers.

N. OTHER ISSUES

Findings outside the scope of this assessment that were brought to the attention of the Working Group Assessment Team include the following: (1) groundwater monitoring indicates migration of Cm-244 from the SWSA 5; (2) at some buildings, secondary and even primary filtration occurs outside the building; (3) some buildings have marginal secondary containment barriers; and (4) much "corporate" knowledge about the facility resides only in the memories of long-term employees. Although not restricted to ORNL, the loss of knowledge could hamper ORNL's efforts to plan and conduct remediation activities for the materials stored in this facility. An aggressive oral history program may help mitigate this loss.

2.5 WEST VALLEY DEMONSTRATION PROJECT SITE

The West Valley facility was originally built to reprocess spent commercial nuclear fuel. Reprocessing activities have long since ceased. It is now the site of the West Valley Demonstration Project. At West Valley, the Fuel Receiving and Storage Facility was originally designed for the receipt, short-term storage, and handling of spent nuclear fuel assemblies, Photo 23. It was designed to store 924 fuel assemblies from commercial nuclear power plants, but it no longer has that capacity. The facility's current mission is to store 40 pressurized water reactor and 85 boiling water reactor fuel assemblies now owned by the Office of Civilian Radioactive Waste Management (RW) and awaiting approval for offsite shipment. All of the fuel is zircaloy-clad. These spent fuel assemblies have been in the Fuel Receiving and Storage Facility since 1973 or 1974, when they were shipped to West Valley. The Fuel Receiving and Storage Facility's storage pool is a single-walled, unlined, concrete-reinforced structure, 75 feet by 40 feet long and 29 feet deep. Storage racks and storage canisters are made of aluminum. Corrosion did not appear to be excessive. The fuel itself was last inspected in 1989 and videotapes taken at that time show some breaches in the cladding.

The vulnerabilities identified included the uncertain condition of the spent fuel pool and the lack of systems for leak detection and mitigation, which could lead to environmental contamination. The water chemistry program may be inadequate to detect and prevent additional corrosion and cracking of fuel cladding, which in turn could result in leakage of fission products. The actual condition of the fuel is uncertain. Therefore, since the current plan is to move the fuel to another DOE storage location,

23 - Storage Pool, Fuel Receiving and Storage Facility, West Valley Demonstration Project

handling and shipping could cause deteriorated fuel rods to fail, potentially releasing fission products. Margins for prevention of criticality accidents resulting from gross seismic and wind failures have not been analyzed.

The Nuclear Regulatory Commission Licensed Disposal Area at the West Valley site contains a half-ton of buried damaged spent fuel. In addition, the Process Mechanical Cell at West Valley contains spent fuel assembly debris left over from reprocessing. Both the Site Team and the Working Group Assessment Team agreed that this material is owned by the State of New York and is, therefore, outside the scope of the Secretary's spent fuel initiative. However, the teams reviewed information about these two facilities and found no potential vulnerabilities.

2.6 LOS ALAMOS NATIONAL LABORATORY

The Los Alamos National Laboratory (LANL) has two fuel storage facilities: the Omega West Reactor fuel storage pool, and the Chemistry-Metallurgy Research Building.

A. THE OMEGA WEST REACTOR (OWR)

Built in 1956, the OWR is an 8-MW reactor housed in an unreinforced, cinder block building with an internal steel frame. It is located in the Los Alamos Canyon, which has very steep sides, Photo 24. OWR was the site of both classified and unclassified material neutron irradiation studies for DOE programs. It also produced industrial radioisotopes for public use. In December 1992, the reactor was shut down on a temporary basis. At the time of shutdown, the core, consisting of 33 fuel elements, was unloaded and stored in the adjacent spent fuel pool. Seven spent fuel elements previously stored in holding racks within the reactor tank were also placed in the spent fuel pool, making a total inventory of 40 OWR fuel elements. The fuel is stored in the spent fuel pool on a temporary basis awaiting a decision by DOE on restart and future operation of the reactor.

Four vulnerabilities were identified at the OWR facility: (1) natural phenomena hazards (i.e., from falling boulders due to erosion or seismic events), (2) potential impact of the seismically unqualified overhead crane, (3) lack of a safety analysis for long-term storage of fuel in the spent fuel pool, and (4) lack of control of loose fuel element storage within the spent fuel pool.

B. THE CHEMISTRY-METALLURGY RESEARCH BUILDING (CMR)

Mainly constructed of reinforced concrete, the CMR building was built to house research and experimental facilities for analytical chemistry, plutonium and uranium chemistry, and metallurgical research. Fuel handling and storage activities take place in Wing 9, which was added to support those programs requiring hot cell facilities. Prior to suspension of offsite shipments, spent fuel was transferred from the OWR to CMR Wing 9, temporarily stored, and then shipped to a fuel processing site. Currently, Wing 9 houses 46 OWR spent fuel elements in two 20-ton dry storage casks. Storage in these casks is intended to be short term and the facility staff is working on arrangements to ship the fuel elements offsite.

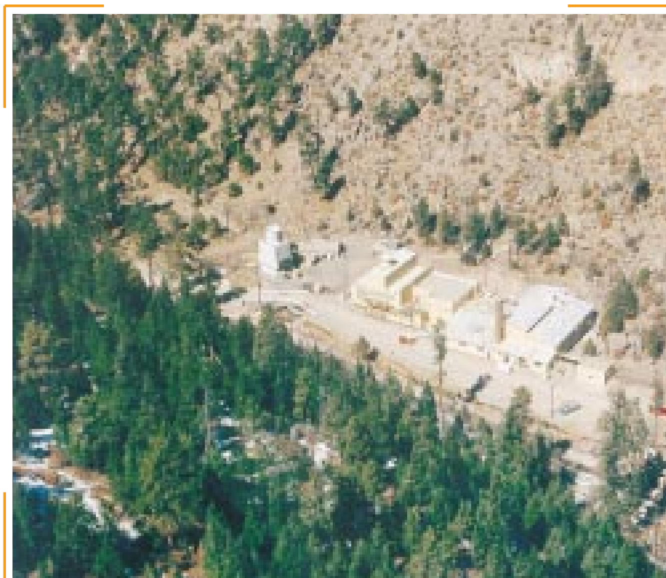
No vulnerabilities were identified for RINM at the CMR facility. However, the current safety analysis report does not address all appropriate aspects of long-term spent fuel storage. The recent justification for continued operation is presumably only valid for a short time.

2.7 BROOKHAVEN NATIONAL LABORATORY

At the Brookhaven National Laboratory (BNL), the High Flux Beam Reactor and the Brookhaven Medical Research Reactor are the two facilities currently storing spent fuel. Targets are not stored with the spent fuel. No buried or classified spent fuels are known to exist at the site.

A. HIGH FLUX BEAM REACTOR (HFBR)

The HFBR is 28 years old and has always been used to produce high-intensity neutron beams for neutron scattering experiments. Currently authorized to operate at a power level of 30 MW, the HFBR produces approximately 63 spent fuel elements per year.



24 - Omega West Reactor, Los Alamos National Laboratory

25 - SPENT FUEL CANAL, HIGH FLUX BEAM REACTOR, BROOKHAVEN NATIONAL LABORATORY

There should be 839 spent fuel elements stored in the fuel canal when this report is issued. Spent fuel from the reactor is stored in an 8-foot by 43-foot canal that is 20 to 30 feet deep. It is located on the reactor's Equipment Level, within the reactor's containment building, Photo 25. No spent fuel elements currently in the canal have been there for longer than 9 years. Water chemistry controls are good, and all spent fuel elements appear to be in good condition. Storage racks in the canal currently contain space for 980 spent fuel elements. It will take over 2 years to fill this space.

The only significant vulnerability identified was the lack of seismically qualified racks and anchorage. Earthquake-caused sliding, tipping, or crushing of the fuel and racks could result in a potential inadvertent criticality that affects worker health and safety. Plans are now being developed to evaluate and strengthen the racks.

B. BROOKHAVEN MEDICAL RESEARCH REACTOR

The Brookhaven Medical Research Reactor is 37 years old. Its mission is to produce neutrons for medical experiments or for material irradiation. It is authorized to operate at power levels up to 3 MW. The reactor core has 32 core locations, 31 of which contain fuel elements. Operation of the Brookhaven Medical Research Reactor does not require frequent refueling: 10 of the 31 elements in the core have been in place since the reactor started up in 1959.

Currently, four spent fuel elements are stored outside of the reactor core. These elements are immersed in primary coolant within the unpressurized reactor tank in an annular storage shelf above the reactor core. A total of 24 storage locations exist around this shelf. Controls on the leakage and water quality of the stored elements are the same as for the 31 fuel elements in the reactor core itself. These controls appear to be adequate. No vulnerabilities were identified.

2.8 SANDIA NATIONAL LABORATORIES

The Sandia National Laboratories (SNL) contain five spent fuel storage facilities: the Manzano Storage Structures, the Annular Core Research Reactor Facility, the Sandia Pulse Reactor Facility, the Hot Cell Facility, and the SNM storage facility.

Only one vulnerability of a generic nature was identified. This was the lack of a currently approved safety analysis that specifically addresses use of the storage facilities for long-term storage of RINM. This vulnerability does not pose an immediate hazard.

A. MANZANO STORAGE STRUCTURES

The Manzano Storage Structures are reinforced concrete bunkers located in the southeast portion of Kirtland Air Force Base. Until recently, when the SNL took responsibility for the site, the Manzano facilities were operated and maintained by the Department of Defense. The SNL currently uses four structures for dry storage of reactor irradiated nuclear material.

B. ANNULAR CORE RESEARCH REACTOR (ACRR)

The ACRR is a pool-type research reactor capable of steady-state, pulse, and tailored transient operation. The ACRR facility includes the reactor pool, one safe, and eight dry floor storage vaults, all located in the high-bay of Building 6588. The ACRR is used primarily for testing electronics and for reactor safety research. The eight storage vaults on the high-bay floor are used to securely store irradiated experiments containing a variety of nuclear materials, but principally U-235. Materials from only three experiments containing RINM are stored at the ACRR facility.

C. SANDIA PULSE REACTOR (SPR) II AND III, AND CRITICAL ASSEMBLY

Three reactors are operated at the SPR facility: SPR II, SPR III, and the Critical Assembly. SPR II and SPR III are unmoderated, fast-burst reactors capable of pulsed and steady-state operation. They are designed to produce a neutron energy spectrum similar to that produced from fission. The Critical Assembly is a small, water-moderated reactor used to perform measurements of key reactor parameters to benchmark the computer calculations and thereby refine the designs for a planned space propulsion reactor. The yard storage holes are 19 stainless-steel tubes located in a corner of the SPR compound. These tubes are surrounded by a high-density concrete monolith. The yard holes are used to securely store irradiated experiments containing a variety of nuclear materials, but principally U-235. All of the materials reside in their own containers, some of which consist of double containment. No plans exist for offsite shipment of the RINM.

D. HOT CELL FACILITY (HCF)

The HCF is a nonreactor nuclear facility at SNL whose principal storage facility is a heavily shielded room. In addition, 13 storage holes exist under the HCF monorail, which are available for storage of irradiated material coming into or out of the HCF. Only one of the holes is in current use and this is for the wet storage of one Savannah River Site (SRS) fuel assembly. The HCF is used to conduct experiments for research programs in materials, fuels, and safety studies. All of the materials are in solid form and are contained in a variety of containers depending on the location and current activity. There are no current plans for offsite shipment of the RINM.

E. SNM STORAGE FACILITY

The SNM storage facility was inaccessible and was studied only through photographs and documents. At this dry storage facility, SNL stores previously failed fuel elements from SPR II and elements from experiments that have been exposed to short irradiations. No vulnerabilities were identified.

2.9 GENERAL ATOMICS

General Atomics has an NRC-licensed facility in San Diego, California. A small amount of DOE RINM is stored in dry wells in the hot cell facility. The RINM consists of irradiated fuel sections from different DOE reactors such as the Reduced Enrichment Research & Test Reactor (RERTR) and the High Temperature Gas Reactor (HTGR). The RINM will remain in place until facility decontamination and decommissioning start. At that time, General Atomics plans to place the RINM inventory in dry cask storage adjacent to the linear accelerator facility. No additional RINM is being stored at this location.

No vulnerabilities were identified. However, the Working Group Assessment Team noted that the RINM at this facility is in the hands of a potentially disinterested landlord. This situation may warrant transfer of this fuel to a DOE facility.

2.10 BABCOCK & WILCOX, LYNCHBURG TECHNOLOGY CENTER

The Babcock & Wilcox (B&W) Lynchburg Technology Center is an NRC-licensed hot cell facility that currently stores a small amount of DOE-owned spent nuclear fuel. This fuel was irradiated in the Oconee and Arkansas Nuclear One commercial reactors as part of a high burnup study conducted by the Office of Nuclear Energy between 1980 and 1989. This program officially terminated in 1992.

No vulnerabilities were identified. However, the current storage contract allows either the Department or B&W to unilaterally choose to terminate this contract by September 1994. Since B&W has apparently decided to exercise its option to discontinue the contract, the Department may want to begin planning alternative arrangements for continued storage of this fuel.

2.11 ARGONNE NATIONAL LABORATORY—EAST

The Argonne National Laboratory East (ANL-E) stores reactor irradiated nuclear materials in the Alpha-Gamma Hot Cell (Building 212, Wing F), the Chicago Pile 5 Building (CP-5), and analytical laboratories within Building 205. The principal mission (past and present) of the Alpha-Gamma Hot Cell is research on the behavior of materials, fuel, and structures used in nuclear reactors. CP-5 houses a defunct, heavy-water, moderated reactor whose fuel has been removed and shipped offsite. Currently, CP-5 is in the process of being decontaminated and decommissioned and contains only two highly enriched uranium target (i.e., converter) elements. Building 205 contains analytical laboratories that perform analyses on gram quantities of spent nuclear fuel samples coming from the Alpha-Gamma Hot Cell.

No vulnerabilities were identified. However, operation of the Alpha-Gamma Hot Cell is totally dependent on programmatic funding. If current program funding is lost, the facility will not be able to ensure continued safe storage of “orphan” fuel (i.e., 20- to 30-year-old stored fuel that is associated with no current program; however, EM-60 may eventually take ownership. In addition, continued storage of the converter elements at CP-5 will hamper the decontamination and decommissioning activities being performed there.

2.12 NAVAL REACTORS FACILITY

The Naval Reactors Facility (NRF) is located on the Idaho Site. This summary is based on the answers to the Question Set provided by NRF personnel (see the Project Plan in Volume II of this report). Because no visit was made to the NRF, this information has not been validated. The Expended Core Facility (ECF), which is on the NRF site, receives all of the spent fuel removed from Naval nuclear-powered ships and prototype reactors. The excess non-fuel structural material is removed at ECF, and the spent fuel is inspected. Upon completion of the inspection/examination work, the spent fuel is shipped to the ICPP for storage, pending eventual placement in a geological repository. Most spent fuel remains at ECF for less than 1 year. One reactor at NRF is shut down but not defueled. The fuel description is classified.

The fuel is stored in critically safe, stainless steel racks. Reportedly, no leakage of fission products from the fuel into the waterpit has occurred. Each spent fuel cell is inspected visually at least once during its residence, which is normally less than 1 year. No vulnerabilities were identified.

2.13 ROCKY FLATS CRITICAL MASS LABORATORY

The discussion below is based on limited written information received from Rocky Flats personnel. No visit was made to the Rocky Flats site. At one time, the Rocky Flats Critical Mass Laboratory (CML) maintained and operated four assembly devices: (1) the Solution System (uranyl nitrate solution in tank form), (2) the Horizontal Split Table (solid fissile material—metal or powder), (3) the Vertical Split Table (solid fissile material—metal or powder), and (4) the Tank Reservoir. Only the Solution System is operational. The other devices have been disassembled, and the plutonium fuel has been placed in storage at various locations within the Rocky Flats complex. Inventory quantities are classified.

No vulnerabilities were reported. No independent validation of this conclusion has been made.

2.14 EG&G MOUND APPLIED TECHNOLOGIES, OHIO

This summary is based on limited written information received from the Mound facility in Ohio. No visit was made to the Mound site and, therefore, no independent validation of this information has been made.

Building 59, the Californium Multiplier Facility (CFX), is a water-moderated, neutron-multiplier facility, which uses aluminum-clad uranium plates to multiply the neutron emissions from Californium-252 for neutron radiographs. The uranium plates are stored in a water bath. A two-story concrete structure approximately 30 feet square, the facility was constructed in 1977 and was operational from that time until it was shut down in 1990. No vulnerabilities were reported.

2.15 LAWRENCE BERKELEY LABORATORY

The following limited information was supplied through the DOE San Francisco Operations Office. Lawrence Berkeley Laboratory has the following sources that were produced at the University of Missouri.

Isotope	Activity	Date
Ge-71	34 mCi	11/13/92
Sm-153/Sc-48	1.3 mCi	12/23/92
Ge-71	24 mCi	6/23/93
Ge-71	0.1 mCi	7/14/93
Ge-71	25 mCi	8/18/93

2.16 BATTELLE COLUMBUS LABORATORY

The limited information below was provided through the DOE Chicago Operations Office. No visit was made to the Battelle site.

As a part of the Battelle Columbus Laboratory Decommissioning Project, a residual of materials from fuel examinations exists within a site hot cell. There are no complete fuel elements, but only fuel pieces that have been previously examined. The material is destined for ultimate storage at WIPP.

No vulnerabilities were reported. No independent validation of this conclusion has been made.

2.17 UNIVERSITY REACTORS

DOE supplies fuel to universities under several contracts. University reactors are licensed by the Nuclear Regulatory Commission. Ultimate disposition of the fuel is being addressed by DOE EM.

No visit was made to any of the university sites and no vulnerabilities were reported.

2.18 OTHERS

Through the DOE San Francisco Operations Office, the following sites were reported to have no inventory of RINM:

- Lawrence Livermore National Laboratory
- Stanford Linear Accelerator Center
- Energy Technology Engineering Center

3 - References

1. Memorandum from H. O'Leary to P. Brush, "Vulnerability Review of Irradiated Materials Currently in Storage," August 19, 1993.

2. Memorandum from Peter N. Brush to all Departmental Elements, "Spent Nuclear Fuel Inventory and Vulnerability Assessment," September 2, 1993.

3. DOE Spent Fuel Working Group "Project Plan for Initial Report on Assessment of Vulnerabilities of Department of Energy Storage of Irradiated Reactor Fuel and Other Reactor Irradiated Nuclear Materials," September 20, 1993.

4. Working Group Assessment Plan, September 1993.

Attachment A - ACRONYMS

SELECTED ACRONYMS

D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
EH	U.S. Department of Energy, Office of Environment, Safety and Health
EIS	Environmental Impact Statement
EM-37	U.S. Department of Energy, Office of Spent Fuel Management and Special Projects
EPA	U.S. Environmental Protection Agency
ES&H	Environment, Safety and Health
HEPA	High Efficiency Particulate Air
M&O	Management and Operating
MT	Metric Tons
NRC	U.S. Nuclear Regulatory Commission
NRF	Naval Reactors Facility
OSR	Operational Safety Requirement
RINM	Reactor Irradiated Nuclear Material
SNF	Spent Nuclear Fuel
SNM	Special Nuclear Material
TRU	Transuranic
TSR	Technical Safety Requirement
USQ	Unreviewed Safety Question

SITE ACRONYMS

ANL-E	Argonne National Laboratory-East
ANL-W	Argonne National Laboratory-West
B&W	Babcock and Wilcox
BNL	Brookhaven National Laboratory
INEL	Idaho National Engineering Laboratory
LANL	Los Alamos National Laboratory
ORNL	Oak Ridge National Laboratory
PNL	Pacific Northwest Laboratory
SNL	Sandia National Laboratory
SRS	Savannah River Site

FACILITY ACRONYMS

ACRR	SNL Annular Core Research Reactor
ARMF	INEL Test Reactor Area, Advanced Reactivity Measurement Facility
BMRR	BNL Medical Research Reactor
BSR	ORNL Bulk Shielding Reactor
CFRMF	INEL Test Reactor Area, Coupled Fast Reactivity Measurement Facility
CMR	LANL Chemistry-Metallurgy Building
EBR II	ANL-W Experimental Breeder Reactor II
ECF	Expended Core Facility
FECF	ICPP-603 Fuel Element Cutting Facility
FFTF	Hanford Fast Flux Test Facility
HCF	SNL Hot Cell Facility
HFBR	BNL High Flux Beam Reactor
HFEF	ANL-W Hot Fuel Examination Facility
HFIR	ORNL High Flux Isotope Reactor
HRE	ORNL Homogeneous Reactor Experiment
ICPP	Idaho Chemical Processing Plant
ICPP-603 FSF	ICPP-603 Underwater Fuel Storage Facility
ICPP-603 IFSF	ICPP-603 Irradiated Fuel Storage Facility
ICPP-666 FSA	ICPP-666 Underwater Fuel Storage Area
ICPP-749	ICPP Underground Storage Facility
MSRE	ORNL Molten Salt Reactor Experiment
NRAD	Neutron Radiography Reactor
OWR	LANL Omega West Reactor
PBF	Idaho Power Burst Facility
PNL-324	Hanford Chemical Processing Laboratory
PNL-325	Hanford Radiochemical Facility and Shielded Analytical Laboratory
PNL-327	Hanford Post-Irradiation Testing Laboratory
PUREX	Hanford Plutonium-Uranium Reduction and Extraction Facility
RBOF	SRS Receiving Basin for Offsite Fuel
RSWF	ANL-W Radioactive Scrap and Waste Facility
SPR	Sandia Pulse Reactor
SWSA	Solid Waste Storage Area
T-Plant	Hanford T-Plant
TAN-607	INEL Test Area North Pool
TRA-603 MTR	INEL Test Reactor Area, Materials Test Reactor Canal
TRA-670 ATR	INEL Test Reactor Area, Advance Test Reactor
TREAT	ANL-W Transient Reactor Test Facility
TRIGA	Hanford Training, Research, Isotopes, General Atomics
TSR	ORNL Tower Shielding Reactor
WIPP	Waste Isolation Pilot Plant
ZPPR	ANL-W Zero Power Physics Reactor

Attachment B - DOE INVENTORY OF REACTOR IRRADIATED NUCLEAR MATERIAL

Site	Facility	Fuel Characteristics: Type	Fuel Characteristics: Number and Form	Estimated Heavy Metal (kg)
Argonne National Laboratory-East	Alpha-Gamma Hot Cell	Experiment samples	Fuel pins, pieces, & pellets	80
Argonne National Laboratory-East	Chicago Pile 5	Research reactor targets	2 targets	1
Argonne National Laboratory-West	Experimental Breeder Reactor II	Research reactor fuel	85 full and 36 half assemblies	17,500
Argonne National Laboratory-West	Hot Fuel Examination Facility	Research reactor fuel	2,047 sub-assemblies & elements	1,000
Argonne National Laboratory-West	Neutron Radiography Reactor	Research reactor fuel	116 fuel elements	1
Argonne National Laboratory-West	Radioactive Scrap and Waste Facility	Research reactor fuel	15,000 sub-assemblies & elements	7,000
Argonne National Laboratory-West	Transient Reactor Test Facility	Research reactor fuel	390 assemblies	14
Argonne National Laboratory-West	Zero Power Physics Reactor	Research reactor fuel	65,600 rods & plates	Classified
Babcock & Wilcox	Lynchburg Technology Center	Commercial fuel rods and sections	3 intact and 17 sectioned fuel rods	44
Brookhaven National Laboratory	Brookhaven Medical Research Reactor	Research reactor fuel	4 elements	1
Brookhaven National Laboratory	High Flux Beam Reactor Canal	Research reactor fuel	839 elements	316
Fort Saint Vrain (1)	Fort Saint Vrain	Commercial fuel	760 HTGR assemblies	16,000
General Atomics	Hot Cell Facility	Various fuel pieces	Fuel pins, pieces, & pellets	4
Hanford Site	105-K East Basin	N-Reactor production fuel	50,683 assemblies	1,152,000
Hanford Site	105-K East Basin	Single Pass Reactor production fuel	138 assemblies	400
Hanford Site	105-K West Basin	N-Reactor production fuel	52,959 assemblies	961,000
Hanford Site	105-K West Basin	Single Pass Reactor production fuel	47 assemblies	100
Hanford Site	200 West Area Burial Ground	Commercial, FFTF and TRIGA fuel	90 fuel pieces	650
Hanford Site	Building 308 Annex (TRIGA)	Research reactor fuel (TRIGA)	101 assemblies	20
Hanford Site	Fast Flux Test Facility	Research reactor fuel	329 assemblies	13,000
Hanford Site	PNL-324	Commercial fuel	7 assemblies	2,400
Hanford Site	PNL-325	Commercial fuel	Intact and sectioned rods and assemblies	12
Hanford Site	PNL-327	Research reactor fuel	Fuel pieces	25
Hanford Site	PUREX Canyon (Basin)	Single Pass Reactor production fuel	779 assemblies	2,800

Site	Facility	Fuel Characteristics: Type	Fuel Characteristics: Number and Form	Estimated Heavy Metal (kg)
Hanford Site	PUREX Canyon (Dissolver Cells)	N-Reactor production fuel	38 fuel elements	300
Hanford Site	T-Plant Basin	Commercial fuel (Shippingport)	72 assemblies	16,400
Idaho National Engineering Laboratory Site	Advanced Reactivity Measurements Facility and Coupled Fast Reactivity Measurements Facility	Research reactor fuel	Intact core	230
Idaho National Engineering Laboratory Site	Advanced Test Reactor Canal	Research reactor fuel	ATR fuel elements & experiments	100
Idaho National Engineering Laboratory Site	Fuel Element Cutting Facility (ICPP-603)	Commercial fuel (Peach Bottom)	2 elements	Not reported
Idaho National Engineering Laboratory Site	Underground Storage Facility (ICPP-749)	Commercial and research fuel	Intact and sectioned rods and assemblies	92,940
Idaho National Engineering Laboratory Site	Irradiated Fuel Storage Facility (ICPP-603)	Commercial reactor fuel	Graphite fuel	500
Idaho National Engineering Laboratory Site	Materials Test Reactor Canal	Commercial fuel and scrap	107 canisters	260
Idaho National Engineering Laboratory Site	Power Burst Facility Canal	Research reactor fuel	PBF driver core	562
Idaho National Engineering Laboratory Site	Test Area North Pad (TAN-607 Pad)	Commercial fuel	Intact fuel elements	38,100
Idaho National Engineering Laboratory Site	Test Area North Pool (TAN-607)	Commercial, LOFT, & TMI II fuel	Intact rods and canned debris	85,400
Idaho National Engineering Laboratory Site	Underwater Fuel Storage Area (ICPP-666)	Naval, commercial, research, & production fuel	Intact and sectioned rods and assemblies	5,620
Idaho National Engineering Laboratory Site	Underwater Fuel Storage Facility (ICPP-603)	Naval, commercial, research, & production fuel	Intact and sectioned rods and assemblies	1,960
Los Alamos National Laboratory	Chemistry and Metallurgy Research Building	Research reactor fuel	46 elements	10
Los Alamos National Laboratory	Omega West Reactor Pool	Research reactor fuel	40 elements	9
Mound (1)	Californium Multiplier Facility	Research	210 fuel plates	2
Naval Reactors Facility (1)	Expended Core Facility	Naval reactor fuel	Not reported	3,500
Oak Ridge Site	Building 3019	SRS production fuel	144 cans	70
Oak Ridge Site	Building 3019	Hanford production fuel	41 cans	23
Oak Ridge Site	Building 3019	Commercial fuel (Canada ConEd)	405 cans	1,215
Oak Ridge Site	Building 4501	Commercial fuel	40 sections	7

Site	Facility	Fuel Characteristics: Type	Fuel Characteristics: Number and Form	Estimated Heavy Metal (kg)
Oak Ridge Site	Buildings 3525, 7920, 7930, 7823A, 7827, 7829	Research reactor fuel	Fuel samples & targets	Unknown
Oak Ridge Site	Bulk Shielding Reactor	Research reactor fuel	41 BSR elements & 32 ORR elements	6
Oak Ridge Site	Classified Burial Ground	Unknown	Unknown	Unknown
Oak Ridge Site	High Flux Isotope Reactor	Research reactor fuel	43 assemblies	404
Oak Ridge Site	Homogenous Reactor Experiment Wells	Research reactor Fuel	135 gallons of uranyl sulphate	Not reported
Oak Ridge Site	Molten Salt Reactor Experiment	Research reactor fuel	LiF and BeF2 salt mixture	38
Oak Ridge Site	Tower Shield Reactor	Research reactor fuel	1 assembly	9
Oak Ridge Y-12 Plant	Building 9201-5	SNAP-10 fuel	36 rods in NaK	5
Oak Ridge Y-12 Plant	Building 9201-5	Research reactor fuel	31 HPRR fuel pieces	204
Sandia National Laboratories	Annular Core Research Reactor	Research reactor fuel	In vaults	1
Sandia National Laboratories	Hot Cell Facility	Research & production reactor fuel	Intact rods & pieces in dry & wet wells	9
Sandia National Laboratories	Manzano Storage Facility	Research reactor fuel	In dry casks	25
Sandia National Laboratories	Sandia Pulse Reactor	Research reactor fuel	In dry wells	29
Sandia National Laboratories	SNM Storage Facility	Research reactor fuel	2 elements in DOT containers	11
Savannah River Site	Building 331-M	Research reactor fuel	305-M test reactor pile	Not reported
Savannah River Site	Building 773-A	Research reactor fuel	4 partial sections	Not reported
Savannah River Site	K, L & P Reactor Disassembly Basins and F & H Canyons	Production fuel and targets	Assemblies and targets	153,700
Savannah River Site	Receiving Basin for Off Site Fuel	Commercial fuel	97 assemblies & cans	3,010
Savannah River Site	Receiving Basin for Off Site Fuel	Experimental material	585 assemblies & cans	19,070
Savannah River Site	Receiving Basin for Off Site Fuel	Foreign fuel	534 assemblies & cans	20,612
Savannah River Site	Receiving Basin for Off Site Fuel	Research reactor fuel	1,304 assemblies & cans	355
Savannah River Site	Receiving Basin for Off Site Fuel	Targets	Assemblies & cans	17,400
West Valley Demonstration Project Site	Fuel Receiving and Storage Facility	Commercial fuel	125 assemblies	26,924

NOTE:

1. Not visited.

Attachment C - WET STORAGE CHARACTERISTICS (1)

		Pool Characteristics									Fuel Characteristics					
Site	Facility	Approximate Age (years)	Capacity (% full)	Lining	Leak Detection System	Ground Water Monitoring	Coolant Treatment System	Equipment/Rack Corrosion	Significant Sludge	Confinement	Type (2)	Cladding	Compositions (3)	Enrichment (4)	Longest Residence Time (years)	Cladding Breach
Argonne National Laboratory-West	Neutron Radiography Reactor	15	0	None	N	N	Y	N	N	Y	R	SS	M	HEU/LEU	0	N
Argonne National Laboratory-West	Experimental Breeder Reactor II (Sodium)	30	85	SS Tank	Y	Y	Y	N	N	Y	R	SS	M	HEU	0.5	N
Babcock & Wilcox	Lynchburg Technology Center	30	N/A	None	Y	Y	Y	N	N	Y	C	Zr	O	LEU	7	N
Brookhaven National Laboratory	Brookhaven Medical Research Reactor	35	20	Tank	Y	N/A	Y	N	N	Y	R	Al	M	HEU	34	Low
Brookhaven National Laboratory	High Flux Beam Reactor Canal	30	90	None	N	Y	Y	N	N	Y	R	Al	M	HEU	10	N
Hanford Site	105-K East Basin	40	60	None	N	Y	Y	N	Y	N	P	Al/Zr	M	LEU	20	50%
Hanford Site	105-K West Basin	40	60	Epoxy	N	Y	Y	N	N	N	P	Al/Zr	M	LEU	6	Canned
Hanford Site	Building 308 Annex (TRIGA)	25	100	SS	N	N	Y	N	N	Y	R	Al	M	SEU	18	N
Hanford Site	Fast Flux Test Facility (Sodium)	10	70	SS	Y	N/A	Y	N	N	Y	R	SS	M/O	LEU/HEU	13	Low
Hanford Site	PNL-327 Pool	30	10	None	N	N	Y	N	N	Y	C/R/P	Al/Zr	M/O	HEU/LEU	10	N
Hanford Site	PUREX Canyon (Basin)	40	N/A	None	N	Y	N	Y	Y	Y	P	Al	M	LEU	20	Unk
Hanford Site	T-Plant Basin	50	100	Epoxy	N	N	Y	N	N	N	C	Zr	O	Nat	15	Unk
Idaho National Engineering Laboratory Site	Advanced Reactivity Measurements Facility (5)	30	100	SS	N	N	N	N	N	Y	R	Al	M	HEU	30	N
Idaho National Engineering Laboratory Site	Advanced Test Reactor Canal	35	90	SS	Y	N	Y	N	N	Y	R	Al	M	HEU	5	N

Attachment C - WET STORAGE CHARACTERISTICS (1)

		Pool Characteristics									Fuel Characteristics					
Site	Facility	Approximate Age (years)	Capacity (% full)	Lining	Leak Detection System	Ground Water Monitoring	Coolant Treatment System	Equipment/Rack Corrosion	Significant Sludge	Confinement	Type (2)	Cladding	Compositions (3)	Enrichment (4)	Longest Residence Time (years)	Cladding Breach
Idaho National Engineering Laboratory Site	Coupled Fast Reactivity Measurements Facility (5)	30	100	SS	N	N	N	N	N	Y	R	Al	M	HEU	30	N
Idaho National Engineering Laboratory Site	Materials Test Reactor Canal	40	10	SS	N	N	N	Y	N	N	C/R	Al/SS/Zr	M/O/C	HEU/LEU/SEU	10	Al cans
Idaho National Engineering Laboratory Site	Power Burst Facility Canal	20	100	SS	Y	N	Y	N	N	Y	R	SS	C	SEU	20	N
Idaho National Engineering Laboratory Site	Test Area North Pool (TAN-607)	40	80	None	N	N	Y	N	N	N	C/R	Zr	O	LEU	18	N; SS & Al cans
Idaho National Engineering Laboratory Site	Underwater Fuel Storage Area (ICPP-666)	10	50	SS	Y	Y	Y	N	N	Y	N/C/R/P	Al/SS/Zr	M/O/C	HEU/LEU	10	N; Al cans
Idaho National Engineering Laboratory Site	Underwater Fuel Storage Facility (ICPP-603)	45	50	None	N	Y	Y	Y	Y	N	N/C/R/P	Al/SS/Zr & none	M/O/C	HEU/LEU/SEU	35	High; Al & SS cans
Los Alamos National Laboratory	Omega West Reactor Pool	40	120	None	N	Y	N	N	N	N	R	Al	C	HEU	3	N
Oak Ridge Site	Bulk Shielding Reactor	40	80	Epoxy	N	N	Y	N	N	Y	R	Al	C	LEU	30	N
Oak Ridge Site	High Flux Isotope Reactor	25	40	SS	Y	N	Y	N	N	Y	R	Al	C	HEU	7	N
Oak Ridge Site	Tower Shielding Reactor	30	100	Al	Y	N	Y	N	N	Y	R	Al	M	HEU	30	N
Sandia National Lab.	Hot Cell Facility	4	100	SS	N	N/A	N	Unk	Unk	Y	P	Al	M	SEU	2	N
Savannah River Site	F-Canyon	40	100	None	Y	Y	N	N	N	Y	P	Al	M/O	LEU	6	Low
Savannah River Site	H-Canyon	40	50	SS	N	Y	N	N	N	Y	P	Al	O	HEU	5	N

Attachment C - WET STORAGE CHARACTERISTICS (1)

		Pool Characteristics									Fuel Characteristics					
Site	Facility	Approximate Age (years)	Capacity (% full)	Lining	Leak Detection System	Ground Water Monitoring	Coolant Treatment System	Equipment/Rack Corrosion	Significant Sludge	Confinement	Type (2)	Cladding	Compositions (3)	Enrichment (4)	Longest Residence Time (years)	Cladding Breach
Savannah River Site	K-Reactor Disassembly Basin	40	50	None	N	Y	Y	Y	Y	N	P	Al	M	HEU/LEU	5	Med
Savannah River Site	L-Reactor Disassembly Basin	40	70	None	N	Y	Y	Y	Y	N	P	Al	M	HEU/LEU	5	High
Savannah River Site	P-Reactor Disassembly Basin	40	40	None	N	Y	Y	Y	Y	N	P	Al	M	HEU	5	Low
Savannah River Site	Receiving Basin for Off Site Fuel	30	70	Epoxy/SS Bottom	N	Y	Y	N	N	Y	P	Al/SS/Zr	M/O	HEU/LEU	30	N
West Valley Demonstration Project Site	Fuel Receiving and Storage Facility	30	10	None	N	Y	N	Unk	N	N	C	Zr	O	LEU	20	Unk

NOTES:
1. Yes (Y), No (N), Unknown (Unk)
2. Production (P), Commercial (C), Research (R), Naval (N)
3. Metal (M), Oxide (O), Cermet (C)
4. High Enriched Uranium (HEU), Low Enriched Uranium (LEU), Slightly Enriched Uranium (SEU), Plutonium (P)
5. Share a single canal

Attachment D - DRY STORAGE CHARACTERISTICS (1)

Site	Facility Characteristics							Fuel/Packaging Characteristics		
	Name	Type	Vintage (Apprx.)	Current Mission	Confinment System(s)	Surveillance Approach	Unique Features	Fuel Type (2)	Fuel Form/Condition	Packaging /Condition
Argonne National Laboratory-East	Alpha-Gamma Hot Cell	Dry wells	1960's	Post-irradiation examination	Negative pressure, HEPA-filtered	100%inspection in progress	Nitrogen atmosphere	C, R	Some good, some degraded	Good
Argonne National Laboratory-East	Chicago Pile 5	Dry well, shipping cask	1950's	Decontamination and decommissioning	Not reported	None	None	R	Good	Good
Babcock & Wilcox - Lynchburg Technical Center	Inside Storage Facility	Hot cell, storage tubes	1970's	Interim storage	Sealed aluminum canisters, negative pressure, HEPA-filtered	Infrequent	NRC-licensed	C	Intact/sectioned fuel rods	Good
Babcock & Wilcox - Lynchburg Technical Center	Outside Storage Facility	Hot cell, storage tubes	1970's	Interim storage	Sealed aluminum canisters	None	NRC-licensed	C	Intact/sectioned fuel rods	Good
General Atomics	Hot Cell Facility	Dry wells	1960's	Post-irradiation examination	Negative pressure, HEPA-filtered	Observed when handled	NRC-licensed	C, R	Fuel pins, pieces	No corrosion
Hanford Site	PNL-324	Hot cells	1950's	Chemical processing laboratory, interim storage	HEPA-filtered	Periodic operational checks	Stainless-steel-lined	C, R	Fuel assemblies, good	Good
Hanford Site	PNL-325	Hot cells	1950's	Waste tank characterization, interim storage	HEPA-filtered	Periodic operational checks	Stainless-steel-lined	C, R	Intact/sectioned fuel rods, good	Good
Hanford Site	PNL-327	Hot cells	1950's	Post-irradiation examination, interim storage	HEPA-filtered	Periodic operational checks	Mobile hot cells	C, R	Fuel pieces, good	Good
Hanford Site	PUREX Canyon	Dissolver cells	Early 1950's	Shutdown, deactivation	Filtered canyon HVAC	None	Fuel elements on dissolver cell floor	P	Corroded, failed fuel elements	None
Argonne National Laboratory-West	Hot Fuel Examination Facility	Hot cells	1975	Post-irradiation examination	Negative pressure, HEPA-filtered	Infrequent, sample basis	Argon atmosphere	R	Subassemblies, elements, good	Various containers
Argonne National Laboratory-West	Radioactive Scrap and Waste Facility	Dry wells	1965	Storage	Seal-welded	Liner upgrade program	Steel-lined, cathodic protection	R	Subassemblies, elements	Inner cans good
Argonne National Laboratory-West	Transient Reactor Test Facility	Dry vaults	1959	Storage	Negative pressure, HEPA-filtered	Monthly	None	R	Very low burnup assemblies	Good
Argonne National Laboratory-West	Zero Power Physics Reactor	Dry vault	1968	Research, non-operational standby	Negative pressure, HEPA-filtered	Observed when handled	Concrete blocks, fuel moved by hand	R	Very low burnup, minor corrosion	Canisters good

Attachment D - DRY STORAGE CHARACTERISTICS (1)

Site	Facility Characteristics							Fuel/Packaging Characteristics		
	Name	Type	Vintage (Apprx.)	Current Mission	Confinement System(s)	Surveillance Approach	Unique Features	Fuel Type (2)	Fuel Form/Condition	Packaging /Condition
Idaho National Engineering Laboratory Site	Fuel Element Cutting Facility (ICPP-603)	Hot cell	1950's	Rack storage preparation	Canned fuel, forced flow HVAC, HEPA-filtered cell	None	Underwater basin connection, lighting needs repair	C	Unknown	Unknown
Idaho National Engineering Laboratory Site	Irradiated Fuel Storage Facility (ICPP-603)	Dry vaults	1974	Interim storage	Forced-flow cell ventilation, HEPA-filtered	No inspection, air particulate monitoring	Shielded, remote operated, transite (asbestos) walls	C, R	Graphite, little corrosion expected	Steel canisters, some cardboard containers
Idaho National Engineering Laboratory Site	Underground Storage Facility (ICPP-749)	Dry vaults	1971-1987	Interim storage	No confinement capabilities, 2nd design controlled atmosphere	Visual inspection complicated, vault air sampling	Underground, steel in concrete grout vaults, cathodic protection	C, R	Intact/sectioned assemblies and rods	Significant aluminum canister corrosion
Idaho National Engineering Laboratory Site	Test Area North Pad (TAN-607 Pad)	Storage casks	1985	Storage	Cask	Contamination surveys, air monitoring	Above ground, TAN area transport cask	C, R	Some holes in cladding	Consolidated canisters, good
Los Alamos National Laboratory	Chemistry and Metallurgy Research Building	Storage casks	1960	Interim storage	Cask	Annual	None	R	Good	No containers
Oak Ridge Site	Building 3019	Dry wells, hot cells	1943	Storage, national U-233 repository	Vessel off-gas system	SNM accounting inspection	Manipulator equipped	P, C, R	Unknown	Canister degradation
Oak Ridge Site	Building 3525	Hot cells	1963	Post-irradiation examination	Negative pressure, HEPA-filtered	Infrequent	Stainless-steel-lined, shielded, master-slave manipulators	R	Highly radioactive capsules	Various containers
Oak Ridge Site	Building 4501	Hot cells, storage cavity	1951	NRC LWR fission gas release research	Vessel off-gas system, HEPA-filtered	Inspected every 1 to 2 years	NRC research	C	Moderately radioactive pieces	Various containers
Oak Ridge Site	Building 7920	Hot cells	1960's	HFIR target prep/process	Double containment provisions, HEPA-filtered	Observed when handled	Commercial research	C, R	Pieces	Various containers
Oak Ridge Site	Building 7930	Hot cells	1964 - 1967	Cf-252 supply	HEPA-filtered	Observed when handled	Heavily shielded	R	Cf-252, metal specimens	Various containers
Oak Ridge Site	Buildings 7823A, 7827, 7829	Dry vaults	1972	Storage	Steel or concrete lid	Health physics surveys	Stainless-steel-lined, concrete collars, sand layers, retrievable cables	C, R	Unknown	Drums, stainless steel capsules

Attachment D - DRY STORAGE CHARACTERISTICS (1)

Site	Facility Characteristics							Fuel/Packaging Characteristics		
	Name	Type	Vintage (Apprx.)	Current Mission	Confinment System(s)	Surveillance Approach	Unique Features	Fuel Type (2)	Fuel Form/Condition	Packaging /Condition
Oak Ridge Site	Molten Salt Reactor Experiment	Criticality-safe tanks	1960's	Storage	Hermetically sealed	Continuously monitored	Shielded, under-ground	R	Solidified fluo-ride salt	No container
Oak Ridge Site	Tower Shielding Reactor	Warehouse	1992	Storage	DOT container	Infrequent	None	R	Fuel pins	55-gallon drums
Oak Ridge Y-12 Plant	Building 9201-5	Warehouse	1950's	Storage	Building ventilation	Continuously monitored	High level of security	R	Very low burnup, HEU	Various con-tainers
Sandia National Laboratories	Annular Core Research Reactor	Dry vaults	1978	Storage	Emergency ventilation, HEPA-filtered	Periodic opera-tional checks	Vaults in high-bay floor	R	Pin segments	Various con-tainers
Sandia National Laboratories	Hot Cell Facility	Hot cell, storage holes	1989	Materials, fuels and safety research	HEPA-filtered	Air monitored	One storage hole in use	R	Solid form	Various con-tainers
Sandia National Laboratories	Manzano Storage Facility	Concrete bunkers	1948	Storage	Natural air circulation, sealed canisters	Routine Health Physics surveys	Buried, bored into mountain	R	Experimental sam-ples, pins	Various con-tainers
Sandia National Laboratories	SNM Storage Facility	Dry vaults	1991	Storage	Forced air, filtered	Routine Health Physics surveys	Modern facility	R	Low burnup, failed fuel compo-nents	Various con-tainers, DOT containers
Sandia National Laboratories	Sandia Pulse Reactor	Dry vaults (yard holes)	1981	Storage	Sealed containers, some double containment	Periodic opera-tional checks	Stainless steel tubes, concrete monoliths	R	No corrosion expected	Stainless-steel/Inconel containers
Savannah River Site	Building 773-A	Hot cell	1950's	Post-irradiation examination	Negative pressure, HEPA-filtered	Infrequent	Aluminum cans	P	Good	Various con-tainers
Savannah River Site	Building 331-M	Steel warehouse	1950's	Storage	Wrapped in plastic and wooden shipping crate	Inspected annually	None	R	Very low burnup	No container

NOTES:
1. Some information in this table has not been independently verified by a Working Group Assessment Team.
2. Production (P), Commercial (C), Research (R), Naval (N)

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